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**Layouts and Operating Criteria for Automation
of Dairy Plants Processing**

**MILK, HALF-AND-HALF, CREAM,
CHOCOLATE DRINK, AND
BUTTERMILK**

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UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Marketing Service

Transportation and Facilities Research Division

Preface

The purpose of this report is to provide dairy plant operators with data and guidelines which can be used in establishing and operating multipurpose milk plants more efficiently. The report deals primarily with the use of and benefits to be derived from automated equipment in a multipurpose milk plant. The study is part of a broad program of continuing research by the Department's Agricultural Marketing Service to find ways of handling the farmer's products more efficiently and at the same time hold down the cost of the products to the consumer.

This is the second of a group of six reports for which work was contracted. The first report is "Layouts and Operating Criteria for Automation of Dairy Plants Processing Milk and Half-and-Half," Marketing Research Report No. 568. Subsequent reports will deal with plants manufacturing ice cream and ice cream novelties; plants manufacturing cottage cheese and cultured milk; cheddar cheese plants; and plants that manufacture sweet cream butter and dried nonfat milk.

Pictures of equipment in this report were contributed by various manufacturers; use of the pictures does not constitute endorsement of the equipment by the U.S. Department of Agriculture. Competitive equipment is available which will perform the same functions.

WASHINGTON, D.C.

Issued September 1963

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Summary

Automated and highly mechanized methods of performing operations and an improved layout can reduce costs for multipurpose milk plants processing market milk, half-and-half, buttermilk, chocolate drink, and coffee cream.

It is estimated that labor costs in multipurpose plants handling 105,000 gallons of milk a week would be about \$58,500 less annually in an automated plant with an improved layout than in a nonautomated plant with a typical layout. The production per man-hour for the automated plant is estimated to be 175 gallons and for a nonautomated plant 109 gallons.

The estimated cost of the equipment required to make these savings is \$146,000 greater than the cost of equipment required for a nonautomated plant. If 20 percent is allowed annually for ownership and operating costs (depreciation, maintenance, insurance, taxes, and interest), the costs would amount to \$29,200, and an annual savings of \$29,300 would result. The savings should amortize the cost of the equipment in about 5 years.

A plant handling 35,000 gallons of milk a week can reduce its labor costs \$32,500 annually and increase its production from 73 to 125 gallons per

man-hour by using automation and improving its layout. The estimated cost of the equipment required to realize this savings is \$95,000. If 20 percent is allowed annually for ownership and operating costs, the costs would amount to \$19,000, and an annual savings of \$13,500 would result. The savings should amortize the cost of the equipment in about 7 years.

Automated operations that make part of this reduction in cost possible are in the receiving of raw milk, in separating, standardizing, pasteurizing, and homogenizing it, and in the cleaning of equipment associated with these operations. The use of highly mechanized equipment in filling and casing cartons, stacking cases, and handling empty cases also accounts for part of the reduction in labor needs.

Layouts are developed for a plant handling 105,000 gallons of milk per week and a plant handling 35,000 gallons per week. The layouts show arrangement of equipment to provide the most efficient flow of products, containers, and supplies through the plants. The layout of each plant provides for future expansion to handle twice the original volume.

Layouts and Operating Criteria for Automation of Dairy Plants Processing

MILK, HALF-AND-HALF, CREAM, CHOCOLATE DRINK, AND BUTTERMILK

BY P. H. TRACY¹

Introduction

A multipurpose milk plant handles a number of items such as bottled milk, half-and-half, coffee cream, buttermilk, and chocolate drink. Many plants of this type throughout the country perform their operations with power-driven machines and manual methods. As a result, production per man-hour is relatively low and operating costs are comparatively high.

Today competition is causing the dairy industry to look to automation to lower costs. Automation is a phase in the evolution of mechanization—a stage in which mechanical operations are brought under automatic controls. It has as its objective the reduction in manpower requirements for performing dairy plant operations without a sacrifice of either healthfulness or quality of the finished product.

The purpose of this study, therefore, is to provide information to operators of dairy milk plants which would assist them in improving their present operating criteria and plant layouts and in making use of automated methods either in the building of new plants or the remodeling of old ones. The objectives of the study are to (1) develop plant layouts showing the equipment types and the equipment arrangements essential for auto-

mated and mechanized methods; (2) show how the plant operates; and (3) estimate the savings resulting from the use of such layouts and mechanized and automated methods.

As used in this report, a nonautomated plant is one that (1) uses manual methods or mechanized methods controlled manually, in the receiving, standardizing, pasteurization, and homogenization procedures and in casing cartons of milk and stacking and unstacking cases, and (2) has no programed procedures for automatic "cleaning-in-place" of equipment.

For the purpose of illustrating the principles of operating criteria, two plants of different sizes were selected. One plant would handle 105,000 gallons weekly and the other, 35,000 gallons weekly. The plans for the plants are intended to illustrate only the principles of layout, design, and size in relation to volume and products handled. These plans are not suggested for any specific market or location.

Dairy plant operators planning the construction of new plants or the expansion of existing plants should consult engineers, dairy technologists, and local health department officials for assistance in the preparation of actual plant designs.

Plant Handling 105,000 Gallons of Milk Weekly

In developing principles and criteria for use in planning new or remodeling old multipurpose milk plants with automated methods, the primary objectives were: (1) To reduce the labor required for receiving raw milk, processing, packaging, storing, and loading out products, receiving and washing empty cases, and cleaning various types of equip-

ment; (2) to maintain the quality of the finished product; (3) to maintain uniformity of product; (4) to reduce in-plant loss; and (5) to remove the drudgery of plant work caused by poorly mechanized methods.

Assumptions With Respect to Plant Operations

Major factors that affect the efficiency of multipurpose milk plant operations are: Variation in the volume of raw milk and milk products handled

¹ The study on which this report is based was conducted and the report prepared by Dr. Tracy under a contract with the U.S. Department of Agriculture. Dr. Tracy was formerly professor of dairy technology, Department of Food Technology, University of Illinois.

from day to day, as well as holiday and seasonal variation; method of receiving raw milk at the plant; variation in the butterfat and solids-not-fat contents of raw milk; number of days a week the plant operates; number of days a week milk is loaded out; volume and type of products processed; number, size, and type of containers in which milk and milk products are packaged; size of cases employed; percent of in-plant loss; operating reserve of milk; excess or shortage of butterfat; and whether a plant makes retail, combination retail-wholesale, or wholesale deliveries.

For the purpose of illustrating principles of plant layout and methods of operation for an automated multipurpose milk plant handling 105,000 gallons weekly, it is assumed that raw milk would be received at the plant in tank trucks and that 80 percent of the volume would be received from local producers and 20 percent from milk marketing associations; raw milk would have an average butterfat content of 3.8 percent and a solids-not-fat content of 8.9 percent; raw milk

would be standardized to a butterfat content of 3.5 percent; 80 percent of the raw milk would be processed as market milk, 8 percent as buttermilk, 6 percent as half-and-half, 4 percent as chocolate drink, and 2 percent as coffee cream; the plant would operate with a butterfat shortage and would purchase cream with 40 percent butterfat content from outside sources; there would be no in-plant loss; milk and milk products would be packaged in half-gallon, quart, pint, and half-pint cartons and a 16-quart universal case would be used for casing cartons.

The assumed inventory and processing schedule for the plant is shown in table 1. Raw milk would be received at the plant 7 days a week; however, milk would be processed only 5 days a week. The plant would be shut down for processing on Wednesday and Sunday, but the same amount of finished products would be sold 6 days in the week—Monday through Saturday.

Since the plant processes milk and milk products only 5 days a week, it is necessary to design the plant with sufficient capacity to produce

TABLE 1.—*An assumed inventory and processing schedule for a plant handling 105,000 gallons of milk weekly*

Milk inventory	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>
Beginning raw milk holdover.....	12, 000	1, 500	0	12, 000	4, 000	4, 000	0
Raw milk receipts ¹	12, 000	21, 000	12, 000	12, 000	20, 000	16, 000	12, 000
Total.....	24, 000	22, 500	12, 000	24, 000	24, 000	20, 000	12, 000
Processed milk:							
Market milk.....	18, 000	18, 000	0	16, 000	16, 000	16, 000	0
Half-and-half.....	1, 350	1, 350	0	1, 200	1, 200	1, 200	0
Buttermilk.....	1, 800	1, 800	0	1, 600	1, 600	1, 600	0
Chocolate drink.....	900	900	0	800	800	800	0
Coffee cream.....	450	450	0	400	400	400	0
Total.....	22, 500	22, 500	0	20, 000	20, 000	20, 000	0
Raw milk holdover.....	1, 500	0	12, 000	4, 000	4, 000	0	12, 000
Finished product sales.....	17, 500	17, 500	17, 500	17, 500	17, 500	17, 500	0
Finished product holdover ²	30, 000	35, 000	17, 500	20, 000	22, 500	25, 000	25, 000

¹ Milk received from milk marketing association by days: Tuesday, 9,000 gallons; Friday, 8,000 gallons; and Saturday, 4,000 gallons. The rest of the milk is received from local producers.

² Finished product holdover includes products held over in both the cold room and refrigerated delivery trucks.

enough products on Monday and Tuesday, plus the carryover, to handle sales on Wednesday and Thursday. The amount of milk and milk products processed each of the 2 days is 22,500 gallons. Since the plant would operate on a shortage of butterfat, 169.2 gallons (1,456 pounds) of 40-percent cream would be purchased from outside on Monday and Tuesday. The 40-percent cream would be received at the plant in 10-gallon cans.

The plant would operate during daytime hours. Only wholesale deliveries would be made, and

trucks would be loaded between 1 p.m. and 9 p.m. for the next day's delivery. Thus, 17,500 gallons of milk and milk products would be put on refrigerated trucks during the afternoon and kept overnight 6 days a week. The finished product holdover shown on the inventory schedule includes finished products stored in the cold room and on trucks. The peak period for storage of finished products in the cold room would be on Tuesday at 1 p.m.; about 34,000 gallons would be in the cold room at this time.

TABLE 2.—Assumed number of containers, by size and product packaged, for a peak day of 22,500 gallons in a plant processing 105,000 gallons of milk weekly

Product	Container				Total
	Half gallon	Quart	Pint	Half pint	
	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>
Market milk.....	21, 600	21, 600	14, 400	0	57, 600
Buttermilk.....	0	4, 800	0	9, 600	14, 400
Half-and-half.....	0	0	10, 800	0	10, 800
Chocolate drink.....	0	1, 200	0	9, 600	10, 800
Coffee cream.....	0	0	0	7, 200	7, 200
Total.....	21, 600	27, 600	25, 200	26, 400	100, 800

The raw-milk inventory is controlled by the amount of milk purchased from a milk marketing association. Since no processing is done on Wednesday or Sunday, deliveries from the milk marketing association are scheduled so that raw-milk storage tanks will be empty on Tuesday and Saturday evenings when processing is completed.

As previously stated, the peak day's production for the plant would amount to 22,500 gallons. The number of containers, by size and content, that would be required for this production is shown in table 2.

Suggested Layout of the Plant

The suggested layout of the plant is shown in figure 1. The components are arranged to give consideration to the flow of products and containers, space utilization, equipment arrangement, and future expansion.

The suggested plant is irregular in shape. Roughly, its depth is 363 feet, and its width at the widest point is 166 feet. It provides about 30,200 square feet of usable floor space. Of this amount, 5,700 square feet is office space.

Components of the Facility

The major components for the proposed plant are: Tanker-receiving shelter; raw-milk storage area; processing and filling room; cold room; truck dock; empty-case storage room; container storage room; dry storage room; laboratories; plant superintendent's office; boiler room; refrigeration equipment room; cleaned-in-place equipment room; locker room; plant entrance; main office; and garage. Figure 1 shows the arrangement of components in the plant layout, and the arrangement of each item of equipment suggested. Each item of equipment in the layout is numbered.

The components are arranged to provide for short and direct paths of flow of products and containers to minimize the amount of piping and wiring needed and labor required. Space requirements for the various components are based on the

items of equipment needed plus an allowance for working space. Sizes of storage rooms are determined by the number and size of items to be stored, the method of stacking, and the length of storage period. Allowances are made in all rooms for aisles, according to the type of traffic handled. The equipment within the various components is arranged for economy of movement of products and containers and for the most efficient performance of operations.

The components of the plant are designed and arranged so that expansion will not present a major construction problem. This is particularly true of the processing and filling room, because experience has shown that it is usually more economical to plan for future expansion of this component at the outset than to remodel or enlarge it later.

In the discussion of the various components the items of equipment within a given component are listed and numbered as they appear in the layout for easy identification.

Tanker-Receiving Shelter

The tanker-receiving shelter is used for receiving raw milk delivered in tank trucks and for cleaning the tanks after delivery.

The suggested shelter, 59 $\frac{1}{4}$ feet long by 30 $\frac{1}{4}$ feet wide, and containing 1,792 square feet of space, provides space for two trucks at a time, so that one may be cleaned while the other is delivering milk. The shelter is of the drive-through type. Platforms extend down the long sides of the shelter and are of a height convenient for workers to reach the manhole on tankers. The platform next to the plant proper is 6 feet wide; the other platform is 3 feet wide.

Located under the platform next to the plant are a receiving pump (2), which pumps milk from tankers at the rate of 180 g.p.m. (gallons per minute), and a cleaned-in-place (CIP) return pump (58), which returns the cleaning solutions to the automatic CIP unit (40) after tanks are washed and sanitized. The CIP unit itself is located in the CIP room.

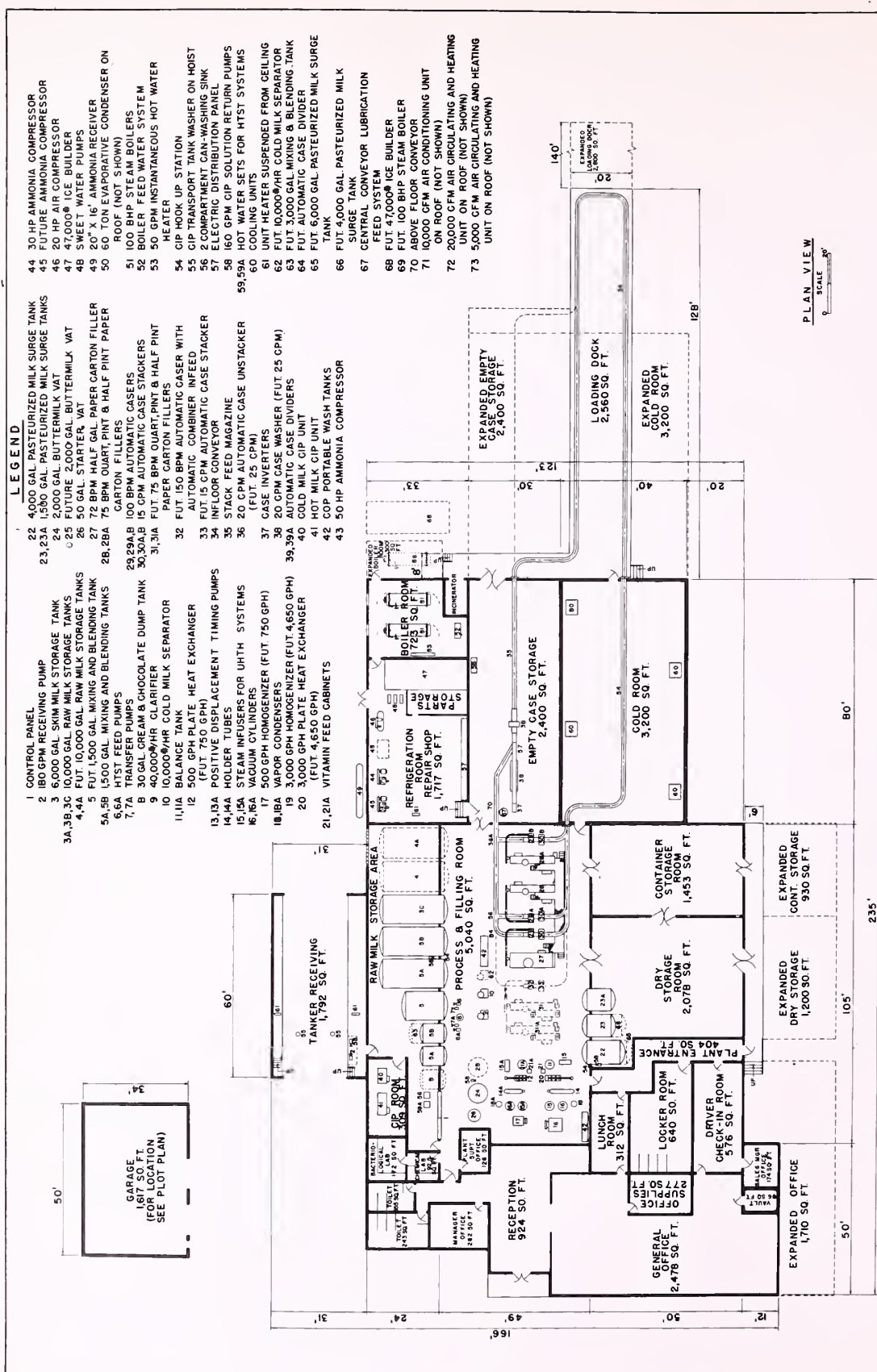


FIGURE 1.—A suggested layout for an automated multipurpose milk plant handling 105,000 gallons of milk and milk products weekly.

Other equipment in the shelter consists of two CIP assemblies (55) for washing transport tanks. The washers are mounted on hoists to facilitate moving them to and from tank manholes. The hoists in turn are mounted on a monorail so the washers may be moved back and forth over trucks with more than one manhole. A hose should be provided for connecting tank trucks with built-in spray balls directly to the CIP unit. Spray balls distribute the cleaning solutions, and the tank-washer assembly is not needed to wash these trucks.

The floor of the shelter should be constructed of reinforced concrete and sloped toward the rear at not less than one-half inch per foot to permit complete and rapid draining of milk from the tank trucks. A floor drain should be located in the center and to the rear of the shelter to carry away wash and rinse water used in cleaning pump compartments on the tank truck. Power-operated doors at each end of the shelter permit it to be closed off from dust and insects while tank trucks are being serviced.

Raw-Milk Storage Area

The room suggested for raw-milk storage tanks also contains mixing and blending tanks, hot water heating and circulating units for the HTST (high temperature, short time) pasteurization system, and a CIP return pump. The area is irregular in shape and contains about 2,056 square feet of space.

RAW-MILK STORAGE TANKS.—An area of the room about 23 feet wide and 76 feet long, or 1,748 square feet, would provide space for three 10,000-gallon raw-milk storage tanks (3A, 3B, and 3C) and one 6,000-gallon raw-milk storage tank (3). It also provides space for two 10,000-gallon tanks if an increase in volume should make them necessary.

These tanks are used to hold raw milk received from tank trucks and to prepare standardized milk (milk adjusted to a standard butterfat content). Tank 3 is used primarily to hold skim milk used in standardizing; however, it can also be used the same as tanks 3A, 3B, and 3C.

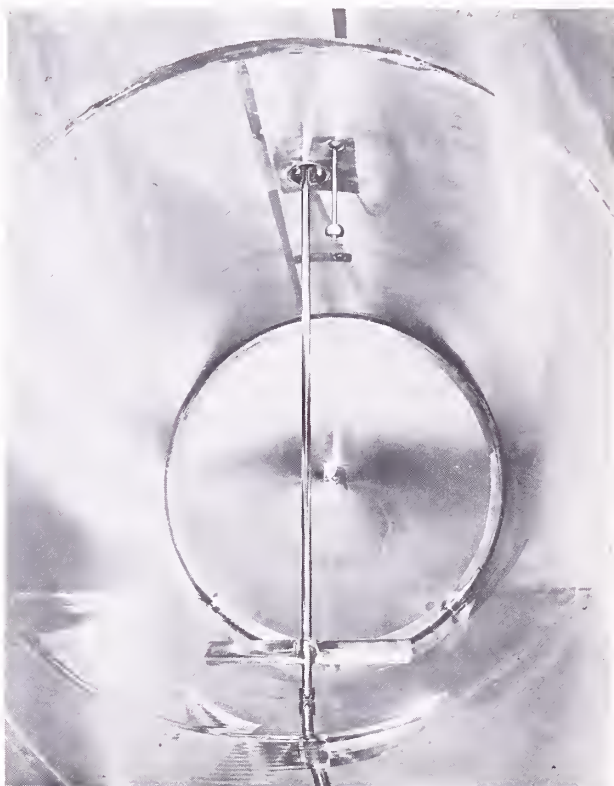
The tanks are located side by side with the heads extending through the wall of the processing room; this location reduces the frequent cleaning of tank exteriors that would be necessary if they were located in the processing and filling room.

The tanks are equipped with agitators, used in standardizing milk, and spray balls, for use with the CIP system (fig. 2).

Each tank has 100 square feet of refrigerated surface on the bottom to provide a normal storage temperature of 40° F. Thermocouples attached to the linings of the tanks are wired to a multi-record instrument in the central control panel where the temperature of the product in each tank is recorded continuously on a strip chart.

For automated weighing of tank contents, tanks should be mounted on four legs, two on each side, with load cells (weight-sensing equipment) attached to the legs on one side. The load cells are connected to the central control panel where a direct reading in pounds of product is given. Electrical impulses from the load cells sound alarms and change valve settings when the tanks are nearly full or nearly empty. They also start motors and change valve settings by remote control. Rubber collars should be installed around the tanks to prevent contact with the wall so there will be no interference with the load-cell system. Several types of load-cell systems are available which will perform the functions described here. Refrigeration service connections to the tanks must be made of flexible materials.

In front of the raw-milk storage tanks and connected to them is a four-line header or manifold system, with air-operated valves that control the flow of product into and out of the tanks.



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FIGURE 2.—The interior of a typical milk tank equipped with a spray ball (at the top) for automatic cleaning and an agitator.

One line is used to deliver raw milk from tank trucks to the storage tanks. The second is for transferring skim milk from the cold milk separator to the storage tanks or for moving skim milk

from one tank to another during standardization. The third is for moving raw milk from a storage tank to the separator or for moving skim milk from a storage tank to the buttermilk vat or the mixing and blending tanks. The fourth is for moving standardized milk from the storage tanks into the HTST system. All four lines can be used at the same time.

CIP RETURN PUMP.—CIP return pump (58) is located between storage tanks 3A and 3B. This pump returns solutions used in cleaning the tanks to the CIP unit in the CIP equipment room.

MIXING AND BLENDING TANKS.—An area about 10 feet wide and 30 feet long or 300 square feet is suggested to hold these tanks and the hot water sets.

Two 1,500-gallon mixing and blending tanks (5A and 5B) are suggested. One tank is used for 12-percent butterfat product and half-and-half, and one for coffee cream and chocolate drink.

These tanks are also connected to a four-line header system in the same manner as the raw-milk storage tanks. One line is used to transfer the 12-percent butterfat product from the separator to the storage tank for it. The second is for moving skim milk from the separator or whole milk from the raw-milk storage tanks to the half-and-half tank or the tank used for coffee cream and chocolate drink. The third is for moving milk products between tanks. The fourth is for moving milk from the mixing and blending tanks into the HTST system.

HOT WATER SETS.—Two hot water sets (59 and 59A) provide hot water for the milk pasteurization system.

Processing and Filling Room

The processing and filling room suggested for the plant is roughly 49 feet wide and 105 feet long and contains approximately 5,040 square feet of space. The room provides space for the control panel, processing equipment, and the filling, casing, and stacking equipment. The walls of the room should be of ceramic tile and the ceiling of a moisture-resistant material. A ceiling height of 14 feet provides ample overhead space for utilities and adequate ventilation. The floor of the room should be constructed of tile or concrete and should slope to all drains. The suggested slope is one-fourth inch per foot.

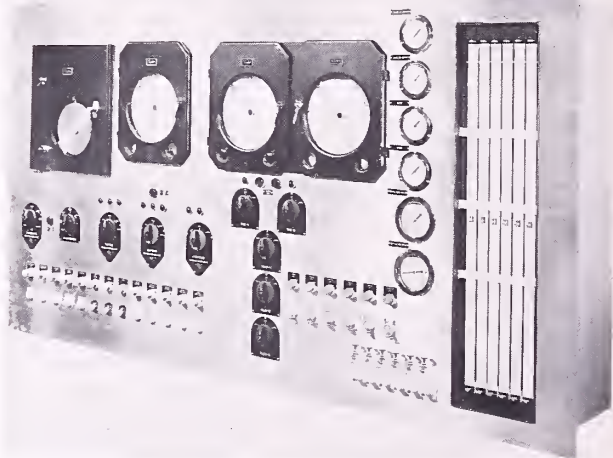
CONTROL PANEL.—The control panel is the center of all the automatic equipment in the plant.

It contains selector switches and pushbuttons for automatically receiving raw milk and for transferring milk and milk products to and from various equipment: a raw-milk temperature-recording chart; a selector switch for automatically determining the weight of milk and milk products; controls for two HTST pasteurization systems including homogenization; individual con-

trols to start or stop equipment used in pasteurization and homogenization; controls to direct the feeding of processed product to the filling machines; individual controls for starting and stopping agitators and refrigeration for various pieces of equipment; selector switches for CIP equipment, and CIP controls and recorders. It also has an air pressure gage to indicate the air supply for remotely operated sanitary valves, a pushbutton to control electric power to instruments in the panel, and a readout that shows the operator what the various switches are set for.

The control panel suggested for the plant is about 5 feet high and 16 feet long. It should be located where it can be easily observed by plant workers and where the back of the panel is easily accessible for service and maintenance work.

A picture of a control panel similar to the one suggested for this plant is shown in figure 3.



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FIGURE 3.—A control panel for an automated dairy plant.

PROCESSING EQUIPMENT.—The processing equipment would consist of two centrifugal transfer pumps (7 and 7A); a cold milk separator with a capacity of 10,000 pounds per hour (10); a 2,000-gallon buttermilk vat (24); a 30-gallon dump tank (8); a 50-gallon starter vat (26); two vitamin feed cabinets (21 and 21A); and two separate systems for pasteurization and homogenization.

The first system, used for market milk, consists of a 3,000-g.p.h. (gallons per hour) HTST feed pump (6); a clarifier with a capacity of 40,000 pounds per hour (9); a 30-gallon balance tank (11); a 3,000-g.p.h. plate heat exchanger (20); a 3,000-g.p.h. positive displacement timing pump (13); a holder tube (14); a steam infuser (15); a vapor condenser (18); a vacuum cylinder (16); a 3,000-g.p.h. homogenizer (19); and a 4,000-gallon surge tank (22).

The second system, used for coffee cream, half-and-half, and chocolate drink, consists of a 500-g.p.h. HTST feed pump (6A); a 30-gallon balance tank (11A); a 500-g.p.h. plate heat exchanger (12); a 500-g.p.h. positive displacement timing pump (13A); a holder tube (14A); a steam infuser (15A); a vapor condenser (18A); a vacuum cylinder (16A); a 500-g.p.h. homogenizer (17); and two 1,500-gallon surge tanks (23 and 23A).

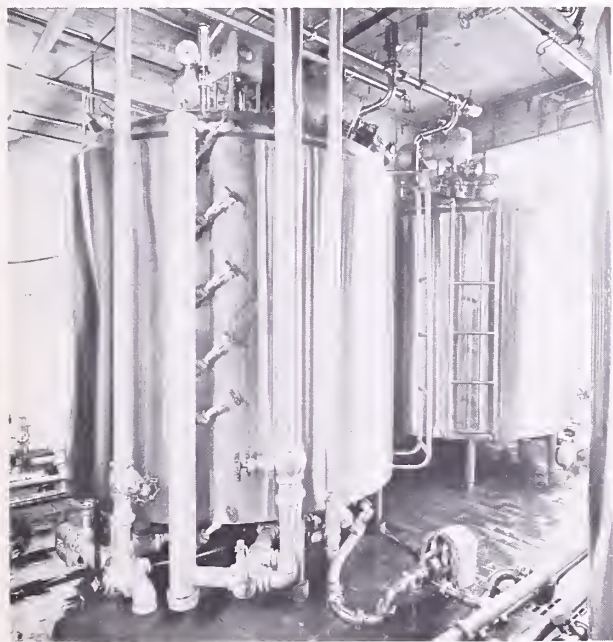
Functions of the equipment are discussed under the different processes for which they are used.

Centrifugal transfer pump 7 is used to pump milk from the raw-milk storage tanks into the separator (10) at a rate of 20 g.p.m. (gallons per minute). The separator separates raw milk into skim milk and a product containing 12-percent butterfat.

Centrifugal pumps (7 and 7A) are used to transfer raw milk, skim milk, 40-percent cream, and the 12-percent butterfat product between tanks and vats when the products prepared in the plant are being standardized.

The 30-gallon dump tank (8) is used in preparing and standardizing coffee cream and chocolate drink.

The 2,000-gallon vacuum pressure vat (24) is used in preparing, standardizing, and pasteurizing buttermilk (fig. 4). The vat is equipped with a vacuum pump; a vacuum relief valve on the vat is used to maintain 10 inches of mercury in the vat during pasteurization to aid in removing volatile off-flavors. The 50-gallon starter vat (26) is



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FIGURE 4.—Vacuum pressure vats used in preparing buttermilk.

used to prepare and pasteurize buttermilk starter. Both vats are equipped with agitators and with steam jackets and refrigerated surfaces.

HTST system No. 1 functions as follows: The 3,000-g.p.h. HTST feed pump (6) feeds raw standardized milk through the clarifier (9) to the balance tank (11). The clarifier removes extraneous material and leucocytes from the milk. The balance tank assures a constant supply of milk in the system; it is equipped with high- and low-level probes for this purpose.

The vitamin feed cabinet (21) provides the vitamin supply for the milk; it is portable and has a refrigerated compartment.

The 3,000-g.p.h. plate heat exchanger (20) heats raw milk to destroy certain bacteria and cools pasteurized milk. It consists of three major sections—a regenerative section, a heating section, and a cooling section. Cold raw milk and hot pasteurized milk flow between alternate plates in the regenerative section so that the cold raw milk cools the hot pasteurized milk and the hot pasteurized milk warms the cold raw milk. The same principle of heat exchange is used in the heating and cooling sections. Hot water from the water heating and circulating unit (59) flows between alternate plates in the heating section and further increases the temperature of the raw milk. Refrigerated water (34° F.) further cools the pasteurized milk in the cooling section.

The positive displacement timing pump (13) sucks milk from the balance tank through the regenerative section of the plate heat exchanger and pushes it to the heating section. The holder tube (14) holds milk for 16 seconds to insure proper pasteurization.

The steam infuser (15), the vacuum cylinder (16), and the vapor condenser (18) make up the ultra-high-temperature heater. This heater insures uniformity of flavor by removing certain feed and weed flavors, which may occur in milk, and improves the keeping quality by destroying additional bacteria. The infuser injects culinary steam into milk and increases the milk temperature. The infuser should be equipped with a moisture and condensate separator at the steam inlet to separate liquid particles from the steam and keep them from entering the infuser. The vacuum cylinder cools milk and removes slightly more water from the milk than was added to it by the steam injection.

The 3,000-g.p.h. homogenizer (19) breaks up the butterfat globules.

The 4,000-gallon surge tank (22) receives milk from the HTST system and serves to maintain a balance in flow rate of milk between the system and the fillers. An air pressure of about 5 pounds maintained in the tank causes milk to flow from the tank to the fillers. The tank is equipped with an agitator and with thermocouples that are connected to the strip-chart recording thermometer in the control panel (1). It is also equipped with

remotely controlled air-operated valves which permit milk to flow to the proper filler.

Equipment in HTST system No. 2 functions in the same manner as that described for system No. 1. Surge tank 23 is used to hold coffee cream and chocolate drink; tank 23A is used for half-and-half.

The surge tanks are located in the dry storage room with the heads extending through the wall into the processing and filling room.

A CIP return pump (58), located near the buttermilk vat (24), returns cleaning solution from the processing equipment to the CIP units.

FILLING, CASING, AND STACKING EQUIPMENT.—The filling, casing, and stacking equipment suggested for the plant occupies about 30 percent of the space in the processing and filling room. The equipment consists of a 72-b.p.m.² (cartons per minute) half-gallon filler (27); two 75-b.p.m. quart, pint, and half-pint fillers (28 and 28A); three 100-b.p.m. automatic casers (29, 29A, and 29B); three 15-c.p.m. (cases per minute) automatic case stackers (30, 30A, and 30B); two automatic case dividers (39 and 39A); an above-floor conveyor system (70); and an in-floor conveyor (34).

The fillers suggested use a plastic-coated flat carton. The filling machine forms the carton, seals the bottom, sterilizes the carton with heat, fills the carton with the proper amount of product, and then seals the top.

The half-gallon filler (27) is used to package market milk only. Quart, pint, and half-pint filler 28 is used for buttermilk, coffee cream, half-and-half, and chocolate drink; filler 28A is used for market milk and chocolate drink.

The automatic casers (fig. 5) place one layer of filled cartons in cases; switches on the machines can change their operation to multitiering, which is required for casing two or three layers of pints and half pints.

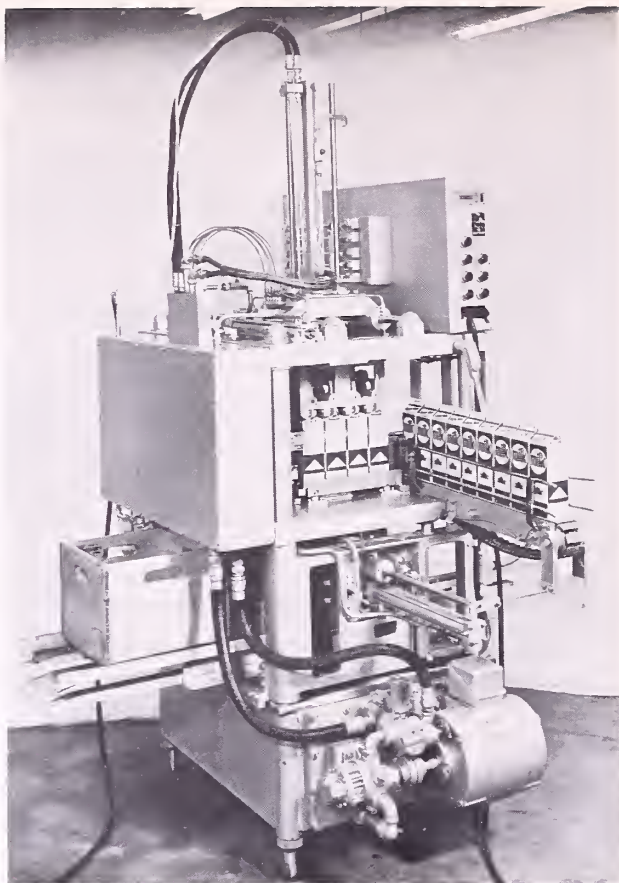
The automatic case stackers stack the cases five high; their capacity is 15 cases per minute.

The above-floor conveyor system moves empty cases from the empty-case storage room to the automatic case dividers, which permit cases to flow to the automatic casers at the rates required for each filler.

The in-floor conveyor moves the stacks of filled cases from the case stackers to the cold room.

CLEANING DISMANTLED MACHINERY.—Two portable wash tanks (42) are located in the processing and filling room for cleaning out of place (COP) equipment which must be partially dismantled for cleaning. The washers are mounted on casters so that they can be readily moved near the items of equipment they are used to clean.

²B.p.m., as used in this report, means cartons per minute to distinguish it from c.p.m., cases per minute.



BN-17433

FIGURE 5.—An automatic paper-carton casing machine. This caser is designed for quart, pint, $\frac{1}{3}$ -quart, and $\frac{1}{2}$ -pint cartons.

Cold Room

A cold room for a wholesale multipurpose milk plant should be designed for receiving, storing, and loading out milk and milk products efficiently (fig. 6). The space requirement for the room should be determined by the volume and type of products to be stored, the sizes of the containers and the size of case used for the products, the methods used in stacking cases, the length of the storage period, and the amount of conveyor space needed to provide for a free flow of products into and out of the room.

Table 1, page 2, shows the daily production, sales, and finished product holdover assumed for the plant. The assumed daily sales amount to 17,500 gallons, and it is planned that this amount be loaded onto wholesale refrigerated trucks between 1 p.m. and 9 p.m. for delivery the following morning. Thus, plant storage would not be needed for this amount.

On the 5 days of the week when the plant is operating, production exceeds sales, and storage



BN-17428

FIGURE 6.—A cold room for storing milk and milk products. Note the steel diamond plate finish on the floor and the in-floor conveyor.

would be needed for the amount not loaded onto refrigerated wholesale trucks. On Tuesday, the carryover, plus Tuesday's production, should be adequate to provide for Wednesday's and Thursday's sales because the plant would be closed on Wednesday. The carryover of finished products from Monday to Tuesday would amount to 12,500 gallons. Tuesday's production would amount to 22,500 gallons; however, storage would not be needed for all of Tuesday's production because loading out for Wednesday's sales would begin about 1 p.m. Approximately 82 percent of Tuesday's production would be completed by 1 p.m. Thus, Tuesday's carryover and Tuesday's production for which storage space would be needed amounts to 30,950 gallons. Because of possible variations in the plant's production and loading out pattern, a safety factor of about 10 percent is suggested in Tuesday's production storage space needs. Thus, the actual volume for which space should be provided would amount to about 34,000 gallons.

The size of case suggested for storing cartons of milk is the 16-quart universal case. It will hold 9 half-gallon containers, 16 quarts, 28 pints, or 44 half-pints. The cases measure 13 $\frac{1}{4}$ inches by 13 $\frac{1}{4}$ inches. However, a $\frac{3}{4}$ -inch clearance allowance between stacks of cases is suggested. Therefore, calculations for storage needs should be based on measurements 14 inches by 14 inches.

The method suggested for storing cases of milk and milk products is to stack them five high, by product. Thus, based on storing a volume of 34,000 gallons (8,500 cases) in stacks five high, cold room storage space would be needed for 1,700 stacks of cases. At 1.36 square feet of space per case, a total of 2,312 square feet of cold room space would be needed for the stacks.

In addition, a 30-percent allowance in the space requirements is suggested for aisles and an in-floor conveyor. Thus, the cold storage room for the plant should contain about 3,200 square feet of space.

A cold room 40 feet wide and 80 feet deep is suggested for the plant. An in-floor conveyor (34) leading from the case stackers in the processing and filling room should run directly through the center of the room onto the wholesale truck loading dock. Only two doors are suggested for the room. One door 3 feet wide would open into the processing and filling room, and one 3 feet wide would open onto the dock.

The cold room should be insulated to provide for economical refrigeration. The floor of the room should be constructed of concrete covered with steel diamond plate. The diamond plate is resistant to wear and makes the work of dragging stacks of cases from and onto the conveyor easier. The floor should slope to a trench-type drain along each side of the in-floor conveyor. A slope of not less than 3/16-inch per foot should be used to insure adequate drainage. Walls and ceiling should be insulated with not less than 4 inches of corkboard, or its equivalent. It is suggested that a smooth cement plaster finish be applied to the walls and ceiling. An inside clear height of 10 feet will allow for adequate air circulation throughout the cold room. Four cooling units (60) are suggested for the room. The refrigeration requirements for the room are discussed in the section entitled "Refrigeration System" in the Appendix.

Truck Dock

A truck dock is suggested for loading milk and milk products onto wholesale delivery trucks and for unloading and storing empty cases. The suggested dock should extend from the cold room and should be 128 feet long and 20 feet wide. It should be covered with a roof 40 feet wide to protect workers and milk products from inclement weather.

The in-floor conveyor (34) leading from the case stackers in the processing and filling room and continuing through the cold room should run down one side of the dock, along the end, up the other side, and into the empty-case room. A 2-foot space between the edge of the dock and the conveyor is suggested as a walkway and work space for truck drivers. Delivery trucks may load milk or unload empty cases from both sides of the dock. Excluding space lost by curves of the conveyor, the total length of usable dock space is about 240 feet, which provides space for 24 trucks at one time. The portion of the dock suggested for storing empty cases would comprise an area about 14 feet wide and 116 feet long in the center of the dock. If 20 percent is allowed for aisle space this area would provide storage for 955 stacks of empty cases.

The floor of the dock should be constructed of diamond plate set in concrete so that workers can easily drag stacks of cases directly onto and off trucks.

Both sides of the dock should be equipped with electric power outlets for operating the refrigeration systems of the parked trucks.

Storage Rooms

Separate rooms are provided for storing empty cases, paper containers, and miscellaneous dry supplies.

EMPTY CASES.—The storage room for empty cases provides space for receiving empty cases from route trucks, storing empty cases, and washing them. The size of the room should be based on the space required for the equipment suggested and the number of cases which would be stored.

The equipment suggested for the room consists of an automatic case unstacker (36), capacity 20 cases per minute; two case inverters (37); a case washer (38), capacity 20 cases per minute; a supply tank (67), which is the central feed system for conveyor lubricant; a double sink (56) for washing cans; and a stack feed magazine (35) for the in-floor conveyor (fig. 7). The in-floor conveyor (34) leads into the empty-case storage room from the truck dock; the above-floor conveyor (70) extends from the empty-case storage room into the processing and filling room.

All items except the double sink and stack feed magazine require an area about 12 feet wide and 35 feet long, or about 420 square feet. The sink requires a working space of about 400 square feet. No space allowance is made for the stack feed magazine because it provides space for storing cases. Total space requirements for the equipment suggested amount to 820 square feet.

The number of empty cases to be stored at one time would be approximately equal to the number of cases used for storing milk in the cold room during the peak storage period—8,250 cases or 1,650 stacks five cases high. However, as previously stated, an area 14 feet wide and 116 feet long (1,624 square feet) on the truck dock would provide space for storing 955 stacks of empty cases. Thus, the empty-case storage room would be required to provide storage for about 695 stacks of cases.

Based on a space requirement of 1.36 square feet per stack and allowing 20 percent for aisle and

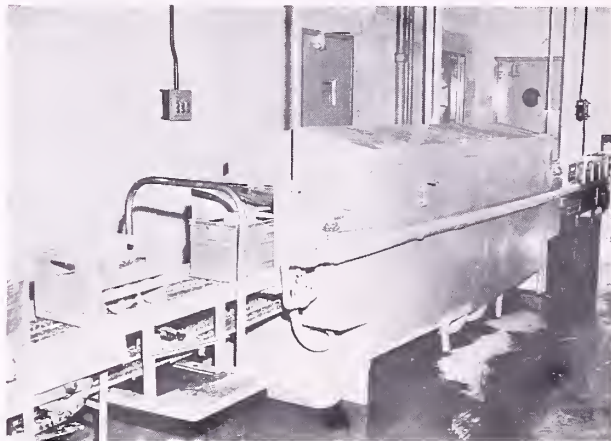


BN-17432

FIGURE 7.—A stack feed magazine and an automatic case unstacker. Note the steel diamond plate finish on floor and the in-floor conveyor.

conveyor space, a total of 1,183 square feet of space would be needed in the empty-case storage room for 695 stacks of cases. The total space requirement for the room—equipment and empty cases—is 2,003 square feet. A room 30 feet wide and 80 feet in length containing 2,400 square feet, is suggested. The additional space provides flexibility in the number of cases stored on the truck dock and in the empty-case storage room.

The stack feed magazine holds 200 cases in stacks five high; the magazine feeds stacks to the automatic case unstacker, where they are unstacked and placed on the above-floor conveyor. This conveyor moves the cases to a case inverter, which tips them over to dump out foreign objects. The cases are next moved to the washer (fig. 8), and then to the second case inverter, which turns them over so they are placed right side up on the above-floor conveyor for movement to the automatic case dividers in the filling room.



BN-17434

FIGURE 8.—This automatic washer cleans 20 cases per minute.

The can-washing sink is used for manually washing cans in which 40-percent cream is received.

The supply tank for conveyor lubricant feeds a soap-and-water lubricating solution through a system of pipes to the conveyor chains.

The floor of the empty-case storage room should be constructed of concrete. Diamond plate flooring is not required as stacks of empty cases drag easily on concrete and do not cause much floor wear.

The ceiling height should be 14 feet, the same as for the processing areas, to provide good ventilation.

The walls and ceiling should be of material impervious to moisture to facilitate cleaning.

It is suggested that the stack magazine (35) be located at a high point on the floor, and that floor drains be located on either side halfway between the stack magazine conveyor and the walls.

Floors should be pitched one-fourth inch per foot to these drains.

CONTAINERS.—This storage room should be designed for receiving and storing paper cartons and for supplying them to the filling room efficiently. Space requirements for the room would be determined by the volume and type of products handled, the sizes of containers in which products are packaged, the supply of cartons maintained in inventory, the method of storing and stacking cartons, and the plant's purchasing policy.

The volume and type of products handled by the plant and the sizes of containers in which products would be packaged have previously been given. It is assumed that cartons would be received at the plant in truckload lots to obtain the benefits from minimum freight rates. The number of cartons comprising a truckload depends on their size; generally, 360,000 containers in the ratio of container sizes assumed for the plant would comprise a truckload. It is assumed that the plant would keep a 2-week supply of containers on hand at all times as a protection against delays in shipment. The number of cartons required weekly is 470,400. To keep a 2-week supply on hand and have space to receive a truckload of cartons, space would be needed for about 1,300,800 cartons.

It is suggested that cartons be received and stored on pallets. The cartons would be in fiber-board cases. A pallet 40 inches square will hold the following number of cartons: Half gallons, 9,600; quarts, 15,000; pints, 30,000; or half-pints, 45,000. Based on these figures, and the ratio of container sizes given for the plant, the 1,300,800 cartons could be stored on about 71 pallets.

A room 29½ feet wide and 49¼ feet long, containing 1,453 square feet, is suggested. This room will provide space for storing 96 pallets, stacked two high, at one time, with 8 inches between the stacks of pallets for air circulation, and an aisle 13½ feet wide. The extra space provided gives the plant flexibility in maintaining an inventory.

A forklift truck of the walk-behind type is suggested for handling pallets.

The container storage room should have doors connecting to the dry storage room, the processing and filling room, and an outside loading dock. The dock should be 6 feet wide and about 50 inches high—the floor height of trucks in which cartons would be received.

The floor of the room should be dustproof concrete. It should be constructed with a slope of ¼ inch per foot to the drain. The walls of the room should be verminproof and flytight; plaster is suggested for the walls. The ceiling should be 14 feet high.

DRY STORAGE.—A room would be needed for storing washing compounds, surplus cases, and miscellaneous items.

The suggested dry storage room would also have space for the three surge tanks (22, 23, and 23A) and a cleaned-in-place return pump (58) used for returning cleaning solution to the CIP unit. The room is 49¼ feet long and 39½ feet wide; the width extends to 49½ feet at one end. The room contains 2,078 square feet.

Construction of the room should be similar to that of the container storage room.

Laboratories

Two laboratories are suggested for the proposed plant—the chemical and the bacteriological. The chemical laboratory is 9¼ feet wide and 10 feet long. This laboratory would be used for making Babcock fat tests and quality control tests. It serves as an anteroom to the bacteriological laboratory.

The bacteriological laboratory is 14 by 12¼ feet. It would be used for making bacteriological examinations of milk products and for storing the mother culture used for buttermilk.

The walls of the laboratories should be of ceramic tile, and the ceiling should be constructed of a moisture-resistant material. The ceiling should be 10 feet high. The floors should slope one-fourth inch per foot to the drains.

Plant Superintendent's Office

A room 9 feet wide and 14 feet deep is suggested for the plant superintendent's office. The room would provide space for a desk and filing cabinets for keeping production records. The walls in the part of the room that extends into the processing and filling room should be constructed of glass to give the superintendent a full view of the machines and control panel. The walls for the rest of the room and the floor should be constructed of tile.

Boiler Room

The boiler room is 25¼ feet by 32¼ feet. An area of the room 7¼ feet wide and 12½ feet deep is for an incinerator. An area containing 723 square feet would be used for housing two 100-boiler-horsepower boilers (51), a boiler feed water system (52), and an instantaneous water heater with a capacity of 50 gallons per minute (53). The method of determining the sizes of the equipment suggested is described in the section entitled "Heating System" in the appendix. The boilers should be arranged in the room to provide ample space for tube removal.

The floor of the boiler room should be of concrete; it should be near ground level to facilitate moving equipment in and out and to provide adequate head room for good ventilation. The ceiling height of the room would be 17 feet. The boiler room should be separated from the rest of the plant with a fire wall, in accordance with the provisions of many building codes. The build-

ing codes should be checked thoroughly before construction is started.

Access to the incinerator room should be from outside the plant to prevent odors of burning trash from penetrating the building.

Refrigeration Equipment Room

The size of the refrigeration equipment room should be based on a careful consideration of the sizes and most efficient arrangement of the equipment suggested for the room: space should be provided also for repairing the equipment. The method of determining the sizes of the refrigeration equipment suggested is discussed in detail in the section entitled "Refrigeration System" in the appendix.

A room 32 $\frac{1}{4}$ feet wide and 53 $\frac{1}{4}$ feet long containing 1,717 square feet, is suggested for the refrigeration equipment. A part of the room, containing 156 square feet, is reserved for a parts storage area. The refrigeration equipment suggested consists of a 50-hp. ammonia compressor (43), a 30-hp. ammonia compressor (44), a 47,000-pound ice builder (47), a 20-hp. air compressor (46), and a sweet-water pump (48). An electric distribution panel (57) contains the main switches and circuit breakers for the plant's electrical system.

An ammonia receiver (49), 20 inches in diameter and 16 feet long, is located just outside and adjacent to the room. A 60-ton evaporative condenser (50) should be located on the roof. The elevated position of the condenser permits the condensed ammonia gas to drain back to the receiver by gravity.

The floor of the room should be of concrete. The walls should be of cinderblock, concrete, or brick. The ceiling should be 17 feet high.

Cleaned-in-Place Equipment Room

A room 12 $\frac{1}{4}$ feet wide and 25 $\frac{1}{4}$ feet deep, containing 309 square feet is suggested for two automatic CIP units (40 and 41). Through controlled circulation of cleaning and sterilizing agents, the automatic units clean equipment parts that come in contact with milk or milk products without the equipment being dismantled. The basic components of the units include solution tanks, automatic valving to provide solution flow paths, and solution feed pumps. The automatic unit (41) has three solution tanks (a rinse, an alkali, and an acid). This unit could be used to clean tanks and tank trucks, cold milk lines, hot milk lines, and the HTST systems. The automatic unit (40) has two solution tanks (a rinse and an alkali). This unit would be used only for cleaning tanks and tank trucks and cold milk lines (fig. 9).

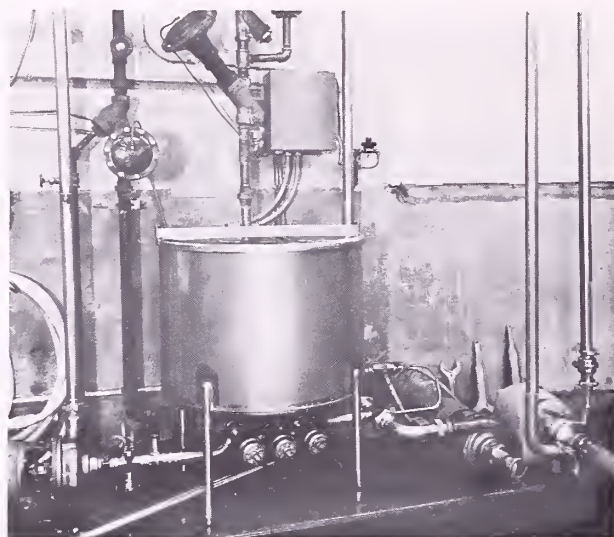
The two CIP units are part of a cleaned-in-place system. Other parts of the system consist of two CIP hookup stations (54), three solution return pumps (58), and two CIP transport washers (55). Both stations are located in the processing room; one solution return pump is located in the tanker-

receiving shelter, one in the raw-milk storage room, and one adjacent to the surge tank in the dry storage room; both washers are located in the truck shelter.

The hookup stations are central places for hooking up the CIP units to the various items of equipment to be cleaned. Each hookup station has a feedline that connects to the CIP unit and other lines that lead to different items of equipment by means of a swing elbow.

The solution return pumps (58) return the cleaning solutions from tanks and vats to the solution tanks of the CIP units.

The transport washers (55) are for cleaning tank trucks.



BN-17430

FIGURE 9.—A typical automatic CIP recirculating unit. Controls for the unit would be located on the control panel.

Main Office

The main office, for the purpose of this report, is made up of the following rooms or areas: General office, office supply room, vault, sales manager's office, drivers' check-in room, lunchroom, a reception room, manager's office, two toilets, and a hallway. The main office area contains about 5,700 square feet. The general office—the office where records would be produced and maintained—is the largest single area: it comprises about 2,478 square feet. The reception room contains 924 square feet. The lunchroom for employees contains about 312 square feet. The drivers' check-in room contains 576 square feet.

Arrangement of Plant Components

The processing and filling room is the focal point of all major production operations. It is centrally located, with the raw-milk storage area, refrigeration equipment room, empty-case stor-

age, cold room, container and dry storage rooms, and plant superintendent's office grouped around it. This location provides for short, direct routes of travel for raw milk, containers, and cases into the room and for cases of packaged milk from the processing and filling room to the cold room.

The tanker-receiving shelter is at the side of the plant next to the raw-milk storage area. This location minimizes the distance milk is pumped from tank trucks and makes the shelter easily accessible to trucks without interfering with other plant operations.

The dock for receiving paper containers and miscellaneous items is at the opposite side of the plant, and the loading dock for wholesale routes is at the rear, so all receiving and loading areas are separate.

The plant superintendent's office gives him a good view of processing and filling operations and the control panel. The chemical and bacteriological laboratories are located so that workers making tests and examinations of milk samples are near the processing and filling room, raw-milk storage area, and receiving shelter.

The refrigeration equipment room is as centrally located as possible with respect to all major areas requiring refrigeration to minimize the amount of piping required.

Location of the boiler room and incinerator at the rear of the plant, out of the way of processing and receiving and loading operations, makes the room readily accessible for fuel deliveries and for moving equipment in and out. Moreover, odors of burning trash in the incinerator would not penetrate the plant.

The cleaned-in-place equipment room is near both the tanker-receiving shelter and the raw-milk storage room so that a minimum amount of piping is required for automatic cleaning.

The main office is located at the front of the building for the convenience of plant patrons.

Provisions for Plant Expansion

The layout for the multipurpose milk plant handling 105,000 gallons per week, shown in figure 1, provides for future expansion to 210,000 gallons. In some instances the expansion would necessitate the addition of more plant area and in others the expansion would be made by the addition of more equipment or by exchanging present equipment for some with greater capacity. Part of the expansion would necessitate adding to both the plant area and the equipment. Some areas of the plant could be expanded by operating two shifts or by staggering shifts. The components which would require more area for the plant to handle 210,000 gallons weekly with a high degree of efficiency are the boiler room, empty-case storage room, cold room, container storage room, dry storage room, truck loading dock, and main office.

Addition of 12,750 square feet would be needed for the plant to handle 210,000 gallons weekly,

or 42 percent more floor space than the suggested plant contains. Excluding the area suggested for office and entrance space expansion, the plant capacity could be doubled by adding 10,830 square feet, or 36 percent more space.

It is suggested that the receiving of raw milk be performed on two shifts; thus the present tanker-receiving shelter should be adequate.

An area 12 feet wide and 25 feet long containing 300 square feet would be added to the boiler room. This addition could be made by removing one exterior wall of the present boiler room.

The empty-case storage room would require an addition 30 feet wide and 80 feet deep, containing 2,400 square feet. The present area would be doubled in size.

The cold room would require an addition 40 feet wide and 80 feet deep, or 3,200 square feet, doubling its present size. This space would be obtained by conversion of part of the truck dock. An area 31 feet by 30 feet, containing 930 square feet of space, would be added to the container storage room. However, this space requirement could be minimized by having more frequent deliveries of empty cartons. An area 30 feet by 40 feet, containing 1,200 square feet, would be added to the dry storage room.

Since 80 feet of the truck dock is converted into cold room space, it is suggested that the truck dock be extended 140 feet. This would provide space for loading or unloading 28 trucks at one time.

The plant entrance would be increased 30 feet in length because of the suggested additions, and 210 square feet would be added to it. The main office would be increased 1,710 square feet. Although the office expansion shown on the layout is at ground level, the possibility of adding needed office space above the present office area should be considered.

Equipment changes or additions which would be required to handle twice the present plant volume would be made in the raw-milk storage area, the processing and filling room, the empty-case storage room, the boiler room, and the refrigeration equipment room.

The raw-milk storage area was originally designed to provide space for the additional tanks required if the plant's volume doubled, and as a result the two 10,000-gallon raw-milk storage tanks (4 and 4A), one 1,500-gallon mixing and blending tank (5), and 3,000-gallon mixing and blending tank (63) can be added with a minimum amount of remodeling and without enlarging the area.

The processing and filling room was also designed to provide space for either larger or additional equipment required if the plant volume increased from 105,000 to 210,000 gallons weekly.

The present control panel is adequate and would require only the wiring needed for the new processing and filling equipment controls.

To convert the processing equipment to handle the increased volume, the equipment changes or additions are as follows: A cold milk separator (62) with a capacity of 10,000 pounds per hour would be added to bring the total separating capacity up to 20,000 pounds per hour; HTST system No. 1 would require that the holder tube (14) and the plate heat exchanger (20) be enlarged to handle 40,000 pounds per hour and that the homogenizer (19) be replaced with one with a capacity of 40,000 pounds per hour; HTST system No. 2 would require that the holder tube (14A) and the plate heat exchanger (12) be enlarged to handle 6,450 pounds per hour and that the homogenizer (17) be replaced with one with a capacity of 6,450 pounds per hour; and a 2,000-gallon buttermilk vat (25) would be added to bring the total buttermilk capacity up to 4,000 gallons daily.

The capacity of the filling equipment would be enlarged. A 6,000-gallon surge tank would be needed in place of one of the present 1,500-gallon tanks, so that the expanded plant would have surge tanks of the following capacities: 6,000, 4,000, and 1,500 gallons (65, 66, and 23A). Additions to the present equipment would consist of two quart to half-pint fillers (31 and 31A) with a capacity of 75 b.p.m. (cartons per minute) each; an automatic caser (32), capacity 150 b.p.m., with automatic combiner infeed (the combiner infeed merges the cartons from two fillers onto the conveyor feeding the caser); an automatic case stacker (33) with a capacity of 15 cases per minute; and an automatic case divider (64).

In the empty-case storage room, the automatic case unstacker (36) and the case washer (38) would be replaced by an unstacker and a washer each with a capacity of 25 cases per minute. The new equipment is about the same size physically as the equipment it would replace.

The area added to the boiler room provides space for an additional steam boiler (69) with a capacity of 100 boiler horsepower to handle the increased heating demands.

The refrigeration equipment room was originally designed to provide space for part of the additional equipment required if the plant's volume doubled. In this room, space is provided for another compressor (45) to handle the additional refrigeration requirements. A 47,000-pound ice builder (68) would also be added, but this unit would be located outside the building adjacent to the expanded boiler room.

Plant Site

The plant site should be of adequate size to provide for the plant proper, principal driveways for connecting the plant with public highways or city thoroughfares, parking for plant trucks and cus-

tomers, a garage, and future expansion. The site should be conveniently located with respect to the area it serves. The site should be fairly level and well drained. It should have easy access to an ample water supply, electrical power, and sewer facilities.

The layout for the plant site is shown in figure 10. The plant is located on a site 400 feet wide and 720 feet deep, which contains roughly 6.6 acres. This width and depth cannot be materially decreased if the suggested plant layout is to be used. Irregularly shaped sites should be avoided if possible. The plant proper comprises approximately 30,200 square feet and is located to one side and to the front of the site. It is suggested that four areas, two directly in front of the building and one to each side, comprising about 25,600 square feet, be landscaped.

Two 40-foot-wide paved driveways connecting the plant with the highway are suggested. Aprons connecting with the major docks of the plant should be not less than 70 feet wide and should have paved surfaces.

A garage, 50 feet by 34 feet, is suggested for storing repair tools and truck parts, and for repairing trucks. It should be easily accessible for trucks and out of the way of traffic to and from the plant. A gas island is suggested near the garage.

Equipment Use Schedule

Equipment selected for the plant is sized to meet the requirements of the daily processing schedule efficiently and economically.

The schedule of equipment use (fig. 11) for the peak processing day of the week shows the time periods necessary for the receiving, separating, standardizing, pasteurizing and homogenizing, and filling containers. In addition to the periods shown for the cleaning equipment, filling machines must be cleaned after they have been used for buttermilk or chocolate drink. On the peak day 18,000 gallons of market milk, 1,800 gallons of buttermilk, 1,350 gallons of half-and-half, 900 gallons of chocolate drink, and 450 gallons of coffee cream are processed.

Receiving Raw Milk

The equipment used in receiving raw milk consists of storage tanks (3A, 3B, and 3C) and receiving pump (2). The letter A on the bar beside each item of equipment in figure 11 indicates the time period the equipment is used for receiving milk on a peak volume day. Receiving raw milk would begin about 5 a.m. and continue intermittently until about 12:30 p.m. About 3,130 gallons would be received in tank 3C and 8,870 gallons would be received in tank 3B. Pump 2 would pump the milk from the tank trucks to the storage tanks. The letter O indicates the time milk with a butterfat content of 3.8 percent is held in the tanks with no operations performed.

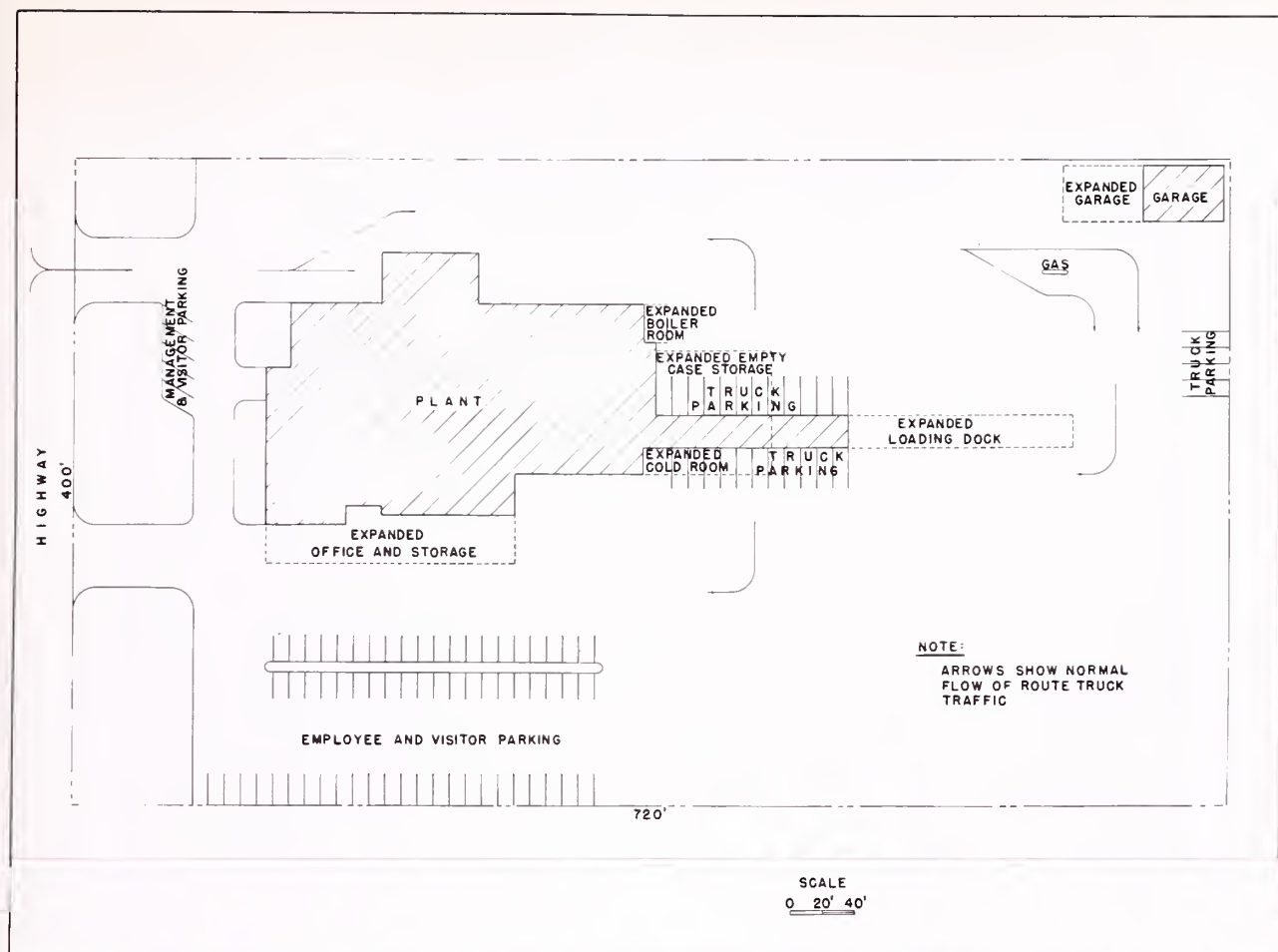


FIGURE 10.—A suggested layout for the site of an automated multipurpose milk plant handling 105,000 gallons of milk and milk products weekly.

Separating

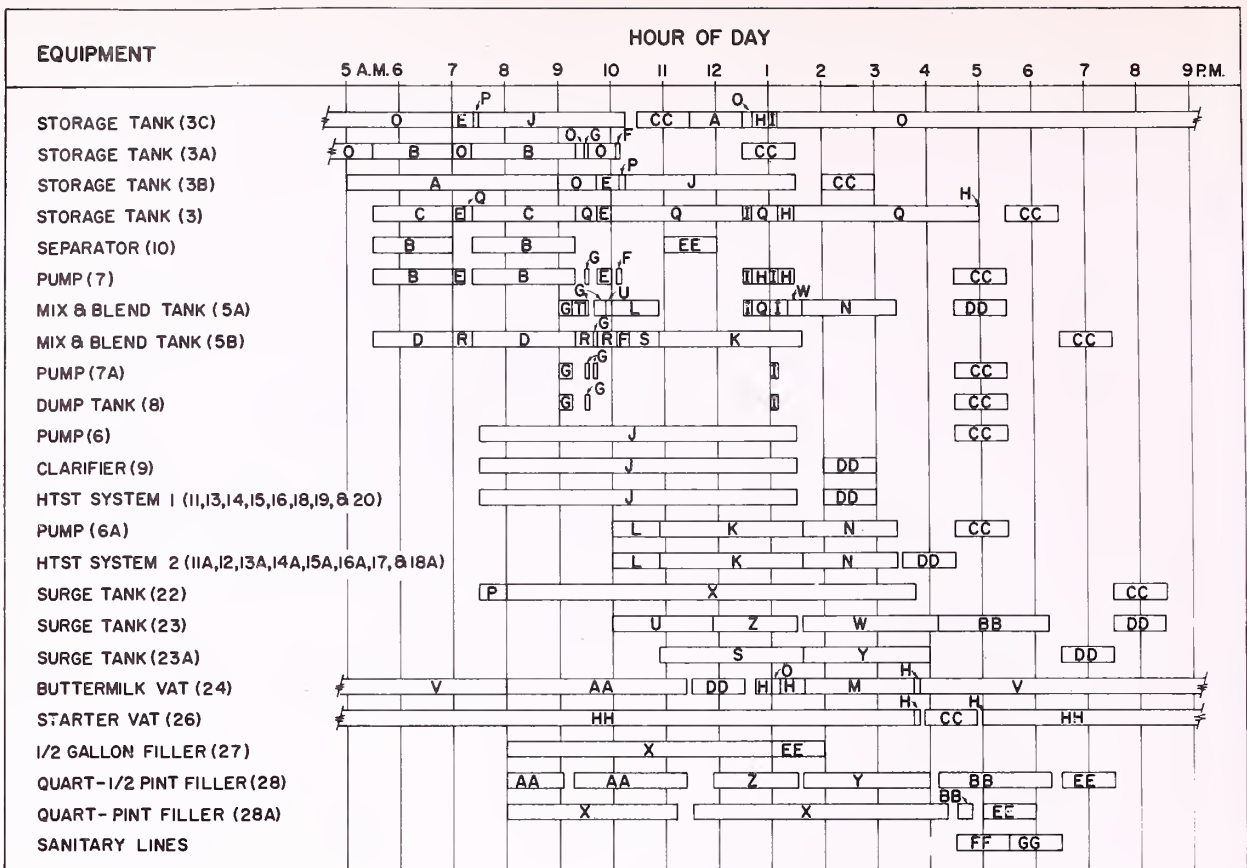
The equipment used in separating raw milk consists of a storage tank (3A), separator (10), and pump (7). The letter B indicates the time period this equipment is used for separating milk. The mixing and blending tank (5B) is used to receive the separated 12-percent fat product and storage tank 3 is used to receive the separated 0.1-percent skim milk. The letters D and C indicate the time periods these items of equipment are receiving separated products. At the beginning of the day, about 4,025 gallons of milk with a butterfat content of 3.8 percent, held over from the previous day in tank 3A, would be separated. Separation would begin about 5:30 a.m. and continue to about 9:20 a.m. Pump 7 would be used to pump the milk to the separator (10). Skim milk, designated on the chart by the letter C, would be diverted to tank 3, and the 12-percent fat product designated by the letter D would be diverted to mixing and blending tank 5B. Separation would be interrupted for about 25 minutes during the period to permit milk in tank 3C to be standardized. The

letters Q and R indicate the time periods that skim milk and the 12-percent fat product are held in the tanks with no operation taking place.

Standardizing

MARKET MILK.—The equipment used in standardizing market milk consists of storage tanks (3, 3B, and 3C) and pump (7). The time periods the equipment is used for standardizing milk are indicated by the letter E. Standardizing raw milk with a butterfat content of 3.8 percent to 3.5 percent butterfat would be performed by pumping skim milk from tank 3 to the raw milk containing 3.8 percent butterfat in tanks 3C and 3B. Standardization would require about 25 minutes for each tank. Pump 7 would be used to transfer skim milk during standardization. The letter P indicates the time periods market milk would be held in the various storage tanks when no operation is being performed.

COFFEE CREAM.—The equipment used in standardizing coffee cream consists of storage tank (3A), mixing and blending tanks (5A and 5B),



LEGEND

- | | | |
|-------------------------------------|----------------------------|-------------------------------------|
| A. RECEIVE 3.8% MILK | M. PROCESS BUTTERMILK | W. HOLD 2.0% CHOCOLATE DRINK |
| B. SEPARATE 3.8% MILK | N. PROCESS CHOCOLATE DRINK | X. FILL 3.5% MILK |
| C. SEPARATED 0.1% SKIM | O. HOLD 3.8% MILK | Y. FILL 11% HALF & HALF |
| D. SEPARATED 12% FAT PRODUCT | P. HOLD 3.5% MILK | Z. FILL 20% COFFEE CREAM |
| E. STANDARDIZE FOR 3.5% MILK | Q. HOLD 0.1% SKIM | AA. FILL 2.0% BUTTERMILK |
| F. STANDARDIZE FOR 11% HALF & HALF | R. HOLD 12% FAT PRODUCT | BB. FILL 2.0% CHOCOLATE DRINK |
| G. STANDARDIZE FOR 20% COFFEE CREAM | S. HOLD 11% HALF & HALF | CC. CLEAN EQUIPMENT (CIP 2 TANK) |
| H. STANDARDIZE FOR 2.0% BUTTERMILK | T. HOLD 40% CREAM | DD. CLEAN EQUIPMENT (CIP 3 TANK) |
| I. STANDARDIZE FOR 2.0% CHOC. DRINK | U. HOLD 20% COFFEE CREAM | EE. CLEAN EQUIPMENT (MANUAL) |
| J. PROCESS MARKET MILK | V. HOLD 2.0% BUTTERMILK | FF. CLEAN RAW LINES |
| K. PROCESS HALF & HALF | | GG. CLEAN PASTEURIZED LINES |
| L. PROCESS COFFEE CREAM | | HH. INTERMEDIATE BUTTERMILK CULTURE |

FIGURE 11.—Assumed schedule of equipment use for processing 22,500 gallons of milk on a peak day. Although not shown in the schedule, machines used for buttermilk or chocolate drink must be cleaned before they are used for other products.

pumps (7 and 7A), and dump tank (8). The letter G indicates the time periods the equipment is used for standardizing. About 450 gallons of 20-percent coffee cream would be standardized in mixing and blending tank 5A. Standardization would begin about 9 a.m. and would be completed about 9:55 a.m. The letter U indicates the time coffee cream is held in tank 5A with no operation being performed.

HALF-AND-HALF.—The equipment used in standardizing half-and-half consists of storage tank (3A), mixing and blending tank (5B), and pump (7). The time period the equipment is used for half-and-half is indicated by the letter F. About 1,185 gallons of 12-percent fat product in mixing and blending tank 5B would be standardized to about 1,350 gallons of 11-percent half-and-half between 10:05 a.m. and 10:20 a.m. The letter S indicates the time period half-and-half is held in tank 5B when no operations are being performed.

CHOCOLATE DRINK.—The equipment used in standardizing chocolate drink consists of storage tanks (3 and 3C), mixing and blending tank (5A), dump tank (8), and pumps (7 and 7A). The letter I is used to indicate the time period for preparing 900 gallons. Standardization begins about 12:30 p.m. and is completed about 1:20 p.m. The letter W indicates the time periods chocolate drink is held in tank 5A when no operation is being performed.

BUTTERMILK.—In standardizing milk for preparation of 1,800 gallons of buttermilk, storage tanks (3 and 3C), pump (7), and buttermilk vat (24) are used. The time period is designated by the letter H. This standardization begins about 12:40 p.m. and is completed about 1:35 p.m.

The letter H is also used to designate the transfer of intermediate culture from starter vat 26 to vat 24 and the placement of skim milk and mother culture in the starter vat.

The letter O designates the time milk with a butterfat content of 3.8 percent would be held in vat 24, and V indicates the time buttermilk is held in vat 24 when no operation is being performed. Buttermilk would be held in the vat overnight.

Pasteurizing and Homogenizing

MARKET MILK.—For the purposes of this report, clarifying is considered a part of the pasteurization and homogenization operations. The equipment used in pasteurization and homogenization of market milk consists of storage tanks (3B and 3C), pump (6), clarifier (9), and HTST system No. 1. The processed milk would flow into surge tank 22. The letter J indicates the time periods the pasteurization and homogenization equipment is used in processing market milk, and the letter P indicates the time the processed milk is held in surge tank 22. Processing of market milk would begin about 7:30 a.m. and continue until approximately 1:30 p.m.—a total of 6 hours. Tank 3C

would supply raw standardized milk for processing from 7:30 a.m. to about 10:15 a.m. and tank 3B would supply it from 10:15 a.m. to 1:30 p.m.

COFFEE CREAM.—Coffee cream would be processed between about 10 a.m. and 10:55 a.m. The equipment used consists of mixing and blending tank (5A), pump (6A), and HTST system No. 2. The coffee cream would flow to surge tank 23. The letter L indicates the time periods for the processing equipment, and the letter U indicates the time coffee cream is held in the surge tank.

HALF-AND-HALF.—The equipment used in pasteurizing and homogenizing half-and-half is mixing and blending tank (5B), pump (6A), and HTST system No. 2. The letter K indicates the time periods the equipment is in use. Half-and-half would be processed between about 10:55 a.m. and 1:35 p.m. Pump 6A would pump half-and-half to the HTST system No. 2. The half-and-half would then flow into surge tank 23A. The letter S indicates the holding time for half-and-half in the surge tank.

CHOCOLATE DRINK.—Chocolate drink would be processed between about 1:35 p.m. and 3:25 p.m. This processing involves using pump 6A and HTST system No. 2. The chocolate drink would flow from mixing and blending tank 5A through the processing equipment, and into storage tank 23. The letter N indicates the time periods for the processing equipment, and W indicates the holding period in the surge tank.

BUTTERMILK.—Buttermilk is pasteurized and cooled in vat 24 between about 1:35 p.m. and 3:40 p.m. Buttermilk starter from vat 26 is transferred to vat 24 at the completion of the pasteurizing and cooling cycle. Compressed air is used to move the starter from vat 26 to vat 24. Buttermilk is held overnight in vat 24 and flows directly to the filler when ready for packaging. The letter M indicates the time periods for the processing equipment, and V indicates the holding period in the vat.

Filling Cartons

MARKET MILK.—After processing begins, at 7:30 a.m., market milk starts to accumulate in surge tank 22. The half-gallon filling machine (27) and the quart-pint filling machine (28A) would be started at 8 a.m. The total time for filling cartons with market milk is about 8 hours. The two machines would operate simultaneously for only about 4 hours and 40 minutes. The letter X indicates the time periods the filling equipment is used.

BUTTERMILK.—Filling operations for buttermilk would be from about 8 a.m. to 11:25 a.m. Buttermilk would flow directly from vat 24 to filling machine 28. The time periods the equipment is used are indicated by letters AA. The filling machine must be cleaned and sterilized before it is used for another product.

COFFEE CREAM.—Coffee cream would be put into cartons from about 11:55 a.m. to 1:30 p.m., and would flow from surge tank 23 to filling machine

28. The time periods the equipment is used are indicated by the letter Z.

HALF-AND-HALF.—Filling operations for half-and-half would be from about 1:35 p.m. to 4 p.m. Half-and-half flows from surge tank 23A to filling machine 28. The letter Y indicates the time periods for the equipment.

CHOCOLATE DRINK.—Chocolate drink would be put into cartons from about 4:10 p.m. to 6:20 p.m. and would flow from surge tank 23 to filling machines 28 and 28A. These machines would operate simultaneously for only about 15 minutes. The time periods for equipment are indicated by the letters BB. After filling is completed, the filling machines must be cleaned to prevent discoloration of the product that follows.

How the Plant Operates

Control panel operations are automated or remotely controlled operations of the plant, and other operations are highly mechanized or manually performed. Only major operations performed in the receiving, processing, packaging, and handling of milk and milk products are discussed here. The flow of milk and milk products through receiving, processing, and packaging is shown in figure 12. Operations which are performed periodically, such as receiving empty paper containers, making laboratory tests, or maintaining the refrigeration or heating system, are not discussed.

Control Panel Operations

Each number on the control panel shown in figure 13 is the same as the number of the item of equipment it controls. The numbers of the various items of equipment are shown on the suggested layout (fig. 1).

Pushbutton 1 supplies power to the instruments in the control panel.

The various features of the control panel are discussed under the following designations: Receiving raw milk, separating, standardizing, pasteurizing and homogenizing, agitator and refrigerant controls, flow of milk and milk products to fillers, and cleaned-in-place equipment.

Receiving Raw Milk

To receive raw milk from a tank truck, the operator connects the sanitary hose of the receiving pump (2) to the tank truck outlet. The receiving operation itself is then conducted from the control panel. The control panel has a "Receive to" switch and a button just below the switch which controls the flow of milk to each of the three raw-milk storage tanks (3A, 3B, or 3C). The tank in which the milk is to be received is selected on the "Receive to" switch, and the button just below it is pushed to start the receiving pump and to arrange the air-operated valves in the header system in front of the tanks so that milk will flow

into the tank selected. The air-operated valves in the header system are interlocked; if a tank is selected and the line is already in use, the valve to it will not open.

Three minutes before a tank is full, an alarm horn sounds to warn the operator, and a red light just below the "Receive to" selector switch comes on. The operator can stop the alarm and shut off the red light by pressing the "Alarm stop" button just to the left of the red light and select another tank. If the "Alarm stop" button is not pressed before 3 minutes are up, the receiving pump automatically stops and the inlet valve to the raw-milk storage tank closes.

"Pump No. 2" pushbuttons on the control panel are for starting and stopping the receiving pump if the system is not functioning properly.

The control panel is equipped with a selector switch and an indicator for weighing the milk in any one of the four raw-milk storage tanks. To determine the amount of milk in a particular tank, the operator turns the selector switch to the tank; the indicator above the switch shows the weight of the milk. If milk is to be added to a partly filled tank and the weight of the added milk is desired, weight readings must be taken before and after the milk is added.

To determine the total amount of milk in all tanks, the operator must take a weight reading for each tank and total the figures.

Temperatures of all products in the raw-milk storage tanks are recorded on a "Strip Chart Recorder" located in the upper left-hand corner of the control panel.

Separating

The cold milk separator (10) is adjusted to separate raw milk into skim milk and a product with 12-percent butterfat content. The 12-percent butterfat product is pumped to a mixing and blending tank, and skim milk is diverted back to the skim-milk storage tank (3).

In separating milk the operator first selects the raw-milk storage tank from which milk is to be taken by turning the "Separate from" switch on the control panel to the number of the tank. Button No. 10 on the panel is then pushed to start the separator (10). The centrifugal transfer pump (7) is started and stopped after running momentarily by pushing the start and stop button No. 7. This provides milk for lubricating separator seals. When the separator is up to proper speed the raw-milk storage tank and the mixing and blending tank to which skim milk and the 12-percent butterfat product are to be diverted are selected on the "Skim to" and "Cream to" switches on the control panel. Button No. 7 is then pushed again to start the centrifugal transfer pump (7) to start the separation of milk.

The raw-milk storage tanks are equipped with alarms which sound off when the level of milk drops to 1,000 pounds. This allows the operator

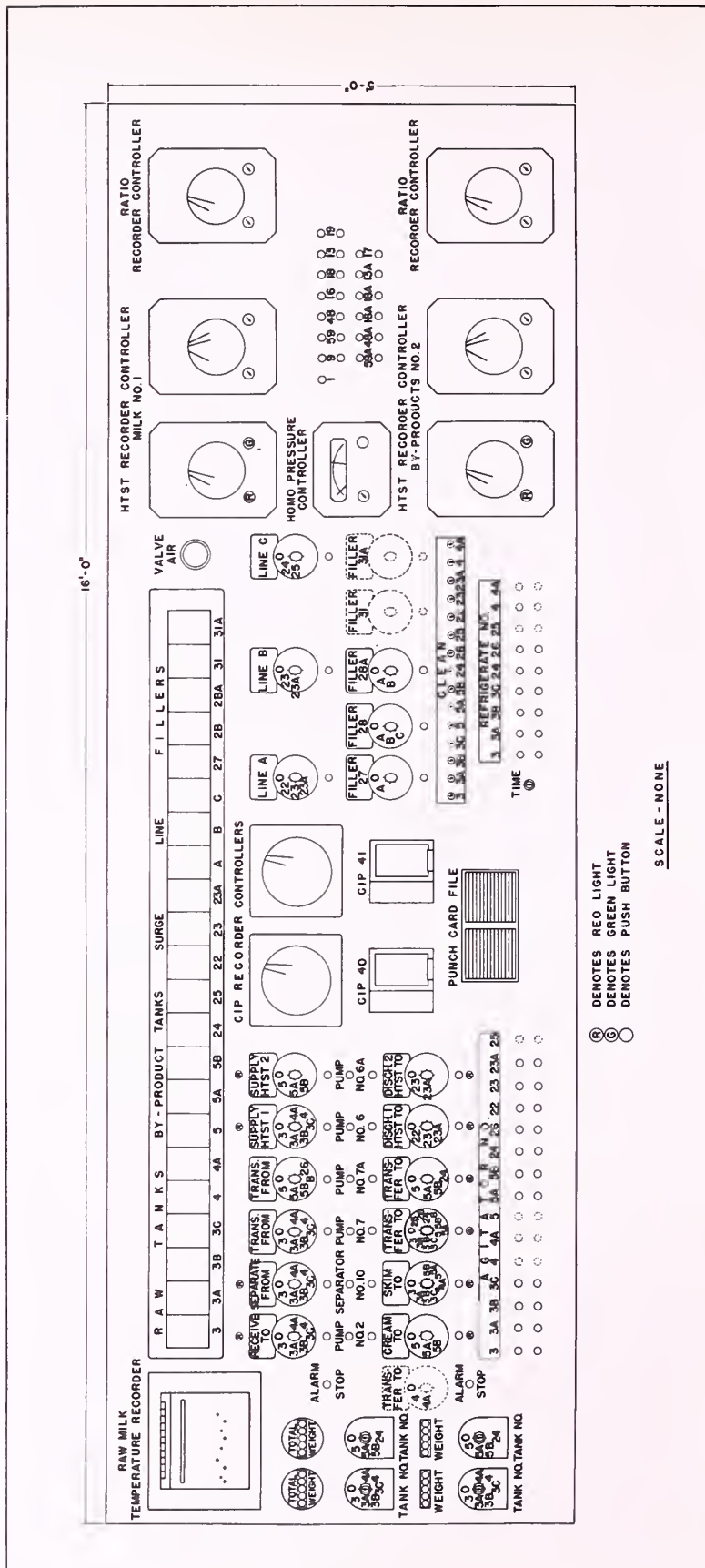


Figure 13.—A suggested control panel for an automated multipurpose milk plant handling 105,000 gallons of milk and milk products weekly.

6 minutes to select another raw-milk storage tank for drawing milk if more milk is needed. The tank would be selected in the same manner as previously described.

The separation process is stopped by turning the "Separate from" switch to "off" position, and pushing stop buttons 7 and 10 for the centrifugal transfer pump (7) and the separator (10).

The total amount of milk withdrawn from a tank can be determined by using the weight selector switch and taking weight readings on the tank before and after separating. The amount of 12-percent fat product obtained can also be determined by use of the weight selector switch connected to the mixing and blending tanks.

Standardizing

MARKET MILK.—The raw milk to be standardized is weighed in the manner previously described, and a sample of the milk is taken from the sample cock in the manhole cover of the tank and tested for butterfat content in the laboratory. The operator then determines the amount of skim milk needed for standardizing by consulting a prepared chart and adds the weight of the skim and raw milk to obtain the total weight of the milk when standardized. This weight is set on the "Total weight" indicator.

The tank selector switch below the "Total weight" indicator is set to the tank number in which the raw milk to be standardized is held. This connects the "Total weight" indicator to the load cells under the tank. The skim-milk tank number is set on the selector switch "Transfer from" and the raw-milk tank number is set on the selector switch "Transfer to." The button beneath the "Transfer from" selector switch is then pushed. This opens the inlet-outlet valves on both the raw-milk and skim-milk tanks, sets the air-operated valves in the manifold in front of the tanks in the proper positions to transfer skim milk to the raw milk, and starts transfer pump (7) in operation. If the agitator in the raw-milk storage tank is turned on when the button is pushed, it automatically turns off.

When the total weight in the raw-milk tank reaches the weight set on the "Total weight" indicator, transfer pump 7 automatically stops, skim-milk and raw-milk tank valves close, and the agitator in the raw-milk tank starts automatically. After the milk is agitated for 10 minutes, a green pilot light turns on to indicate that the standardization process is complete. The operator turns the "Transfer to" selector switch to "off" position. A recheck on butterfat would be made at this point. If unsatisfactory, a further addition of the needed ingredient would be made by the procedure described above.

The centrifugal transfer pump (7) can be operated manually with the start and stop pushbuttons on the control panel with the "Transfer to"

selector switch turned to the "off" position, should a situation warrant it.

COFFEE CREAM.—Coffee cream with a butterfat content of 20 percent, would be made up in mixing and blending tank 5A by combining 40-percent cream, the 12-percent butterfat product, and 3.8-percent raw milk in the proper proportions.

The 40-percent cream is put in the tank first by way of the dump tank (8). The operator sets the "Transfer from" selector switch to dump tank 8, and sets the "Transfer to" selector switch to blending and mixing tank 5A. He starts centrifugal transfer pump 7A by pushing button No. 7A. Then seventeen 10-gallon cans of 40-percent cream are manually emptied into the dump tank and pumped into the mixing and blending tank. Button No. 7A is pushed to stop the pump when all the cream has been pumped through.

The weight of the cream in the mixing and blending tank is then checked by using the weight indicator, and the amounts of raw milk and 12-percent butterfat product necessary are determined by consulting a chart.

The raw milk is added first; it is pumped into the mixing and blending tank by way of the dump tank to remove the 40-percent cream from this tank. The 12-percent butterfat product is pumped directly into the mixing and blending tank. These products are added by setting the total weight indicator and the "Transfer from" and "Transfer to" switches on the appropriate tanks and starting the proper transfer pump.

Pumping the raw milk through the dump tank requires selecting the additional tank numbers on the second set of "Transfer from" and "Transfer to" switches and starting both transfer pumps (7 and 7A).

At the end of the transfer of the 12-percent butterfat product, the agitator in tank 5A starts automatically and after a 10-minute run a green light under the "Transfer to" selector switch comes on, indicating a check test of butterfat should be made. This normally concludes the preparation of coffee cream.

HALF-AND-HALF.—Eleven-percent half-and-half would be made up in mixing and blending tank 5B by combining the proper proportions of 3.8-percent raw milk and the 12-percent fat product, in the same manner as described for preparing standardized market milk.

CHOCOLATE DRINK.—Chocolate drink with a butterfat content of 2 percent would be made up in mixing and blending tank 5A after it has been emptied of coffee cream. This product would be made by combining the proper proportions of skim milk, 3.8-percent butterfat raw milk, and chocolate syrup, in the same manner as that described for preparing coffee cream. In this case, the skim milk is first pumped into mixing and blending tank 5A, the chocolate syrup is manually

poured into the dump tank and then pumped into tank 5A, and the raw milk is added to tank 5A by way of the dump tank.

BUTTERMILK.—Cultured buttermilk with a buttermilk content of 2 percent would be made up in the buttermilk vat (24) by combining the proper proportions of 3.8-percent raw milk and skim milk, in a manner similar to that described for preparing standardized market milk.

Pasteurizing and Homogenizing

MARKET MILK.—The HTST system No. 1 would be used for pasteurizing and homogenizing market milk. The surge tank (22) which would be filled is selected on the "Discharge 1 HTST to" switch. The pushbutton just below the switch is then pressed to open the tank's inlet-outlet valve.

The "Supply HTST 1" switch is then turned to the number of the raw-milk storage tank containing standardized milk. This opens the sanitary line valve to deliver standardized milk through the HTST system and to the surge tank. The button under the "Supply HTST 1" switch is pushed. The raw-milk storage tank inlet-outlet valve opens, pump 6 starts, and pumps milk through the clarifier (9) and to the balance tank (11).

When milk rises to the low-level probe in the balance tank the probe automatically causes the positive displacement timing pump (13), the sweet-water pump (48), the hot water set pump (59A), and the vacuum and water removal pump and water level control for the UHTH system to start. Pump 13 draws milk from the balance tank through the regenerative section of the plate heat exchanger where its temperature is raised from 40° to 140° F. It then forces the milk to the heating section where its temperature is increased to 170°. From the heating section milk flows through the holding tube where it is held at that temperature for 16 seconds. It then passes to the flow diversion valve.

If the temperature of milk as it reaches the diversion valve is 161° F. (legal pasteurizing temperature), a relay in the HTST Recorder Controller No. 1 opens the incoming steam line to start the steam infuser, the vacuum cylinder, the product removal pump, and the homogenizer under no-load conditions, and milk passes to the steam infuser (15). If the temperature of milk is below 161° as it reaches the diversion valve, the valve automatically returns it to the balance tank for recirculating and reheating.

In maintaining a constant supply of milk in the system, the balance tank operates in the following manner: When milk coming into the tank from the clarifier and from the diversion valve rises to the height of the high-level probe in the tank, a float modulates a three-way throttling valve in the line to divert cold milk back to the suction (inlet) side of pump (6). This, in effect, cuts off the supply of milk coming from the raw-milk storage tank, causes the milk to recirculate through pump 6 and the clarifier (9), and pre-

vents the balance tank from overflowing. When the supply of milk in the balance tank drops to the low-level probe, the float modulates the three-way throttling valve to divert cold milk from the clarifier to the balance tank.

Cold milk in the balance tank is fortified with vitamin concentrate from the vitamin feed cabinet (21). Vitamin concentrate is automatically metered into the tank when the milk is flowing from the diversion valve to the steam infuser.

The infuser injects culinary steam into milk and raises its temperature to a preset temperature in the range of 196° to 210° F. The milk then passes to the vacuum cylinder where it is immediately cooled to 166° as a result of the drop in pressure. It is discharged from the vacuum cylinder about 4 degrees below its incoming temperature to insure that slightly more water is removed by evaporation than is added by steam.

The ratio-recorder controller modulates the temperature milk attains in the UHTH (infuser and vacuum cylinder) to whatever temperature is selected on the controller. It also records the temperature of milk on a chart in the controller.

Milk is pumped from the vacuum cylinder to the homogenizer.

Milk first flows through the homogenizer, under no-load condition, to the regenerative and cooling sections of the plate heat exchanger where its temperature is decreased from 166° to 38° F. and from the cooling section to a three-way valve in the system. Since the milk is not homogenized, the three-way valve diverts it back to the balance tank. When milk first hits the three-way valve, a contact is made with a sanitary pressure switch which actuates the homopressure controller. The homopressure controller controls a diaphragm mounted on the stem of the homogenizing valve of the homogenizer. This diaphragm automatically raises the pressure of the homogenizer to load conditions and after the homogenizer has operated under load conditions for a preset time, the three-way valve automatically diverts homogenized milk which has passed through the cooling section to surge tank 22.

To stop the HTST system the "Supply HTST 1" switch is turned to "off" position. This stops pump 6 and closes the inlet-outlet valve of the storage tank. The "Discharge 1 HTST to" switch is then turned to "off." This closes the inlet-outlet valve to the surge tank.

Pushbuttons 59, 48, 16, 18, 13, 19, and 9 are for individual operation of various items of equipment. Pushbutton 59 is for the hot water pump, 48 for the sweet-water circulating pump, 16 for the ultra-high-temperature heater, 18 for the vapor condenser, 13 for the positive displacement timing pump, 19 for the homogenizer, and 9 for the clarifier.

COFFEE CREAM, HALF-AND-HALF, AND CHOCOLATE DRINK.—HTST system No. 2 would be used for pasteurizing and homogenizing these three prod-

ucts. This system operates the same as HTST system No. 1 with the following exceptions: It does not have a clarifier and the supply of products to the balance tank is controlled differently.

These products flow directly from their respective mixing and blending tanks through pump 6A to the balance tank 11A. When a supply of a product coming from pump 6A into the balance tank and the supply being diverted from the diversion valve back into the tank rise to a high level, a float modulates a throttling valve, cutting off the supply of product coming from pump 6A. This prevents the balance tank from overflowing. When the supply of a product in the balance tank drops to the lower level, the throttling valve allows the product to flow from pump 6A into the balance tank.

The controls for this system consist of "Discharge HTST 2," "Supply HTST 2," the pump start button 6A, "Recorder Controller Byproducts No. 2," and the "Ratio Recorder Controller No. 2."

The following pushbuttons are used for individual operation of equipment: 59A, 48A, 16A, 18A, 13A, and 17.

Coffee cream would flow to surge tank 23. Half-and-half would flow to surge tank 23A. Chocolate drink would flow to surge tank 23 after tank has been emptied of coffee cream.

BUTTERMILK.—In preparing buttermilk, raw milk with 2-percent butterfat content is pasteurized in the 2,000-gallon buttermilk vat by opening a valve to admit steam to the jacket of the vat. When heating begins, the vat agitator and vacuum pump are started. When the contents of the vat reach 185° F., the steam valve is closed and the product is held at 185° F. for 30 minutes.

After the holding period, the water valve is opened and water is run into the jacket of the vat until the pasteurized 2-percent milk is cooled to 100° F. The water valve is then closed; the vacuum pump is turned off; and 34° F. sweet water is turned into the jacket. The sweet water cools the product from 100° F. to 70° F. before cultured milk starter is added.

In transferring cultured milk starter from the starter vat (26) to the buttermilk vat (24), the operator sets the "Transfer from" switch to vat 26 and the "Transfer to" switch to vat 24 and presses the button just below each switch. This opens the inlet valves of the two tanks. The operator then opens a compressed air valve on the starter vat, and air forces the starter through a sanitary line into the buttermilk vat. When the starter is in the buttermilk vat, the air valve to the starter vat is closed and the "Transfer from" and "Transfer to" switches are turned to "off" positions. The agitator for the vat is turned on for 10 minutes to mix the ingredients. The batch is then allowed to set for about 15 hours so that the acidity of the cultured milk may increase. After the setting period, the agitator is turned on to slow speed, and

34° sweet water is run into the jacket to cool the cultured milk to 40° F.

The starter used would be made from skim milk in the 50-gallon starter vat (26) on the day preceding the manufacture of cultured milk.

The opening and closing of steam and water valves, the starting of the agitator, and the starting and stopping of the vacuum pump for the buttermilk vat are performed manually. These operations could be programed so as to be automatic, but for a plant making only one batch a day, programed operations are not suggested.

Agitator and Refrigerant Controls

Agitation is done automatically only during the standardization or batch makeup processes. To start the agitators at other times, the control panel has the following pushbuttons under "Agitator No.": 3, 3A, 3B, and 3C for the raw-milk storage tanks; 5, 5A, and 5B for the mixing and blending tanks; 24 and 26 for the buttermilk vat and the starter vat; and 22, 23, and 23A for the surge tanks.

Pushbuttons on the control panel under "Refrigerate No." 3, 3A, 3B, and 3C are for circulating 34° sweet water through the refrigerated surfaces of the raw-milk storage tanks. Pushbuttons 24 and 26 are for circulating sweet water through the refrigerated surfaces of the buttermilk vat and the starter vat. These buttons actuate the solenoid valves on the lines to admit sweet water to the refrigerated surfaces and to start the proper sweet-water pump.

Flow of Milk and Milk Products to Fillers

The order of the flow of milk and milk products to the fillers is: Market milk, buttermilk, coffee cream, half-and-half, and chocolate drink. Products from surge tanks 22, 23, and 23A and buttermilk vat 24 are forced through sanitary lines to the fillers by air pressure. Approximately 5 pounds of air pressure is maintained on these tanks during filling operations. The compressor providing air pressure to the tanks should be equipped with intake filters to assure air free from dust and other impurities. The air compressor line to the tanks should be equipped with moisture and scale traps to prevent moisture and foreign products from entering the milk products.

MARKET MILK.—Market milk would flow from surge tank 22 through "Line A" to the half-gallon filler (27) and to quart-pint filler 28A. Selector switch "Line A" would be set on surge tank 22 to connect the sanitary pasteurized milk manifold to the outlet valves of the surge tank. The button underneath the switch is pressed to open the tank outlet valve. Switches "Filler 27" and "Filler 28A" are set to "Line A." The buttons underneath each switch are pushed to open the inlet valves to the filler bowls.

BUTTERMILK.—Buttermilk would flow from the buttermilk vat (24) through "Line C" to filler 28.

Selector switch "Line C" would be set on vat 24 and the button under the switch would be pushed to open the vat outlet valve. Switch "Filler 28" is set to "Line C." The button under the switch would be pushed to open the inlet valve to the filler bowl.

COFFEE CREAM, HALF-AND-HALF, AND CHOCOLATE DRINK.—Coffee cream would flow from surge tank 23 and half-and-half from surge tank 23A through "Line B" to filler 28. Chocolate drink would flow from surge tank 23 through "Line B" to fillers 28 and 28A. The selector switches would be set accordingly and the appropriate buttons pushed.

Cleaned-in-Place Equipment

The control panel contains "CIP Recorder Controllers," punchcard programmers "CIP 40" and "CIP 41," a punchcard file, and "clean" switches. The recorder controllers record the time, temperature, and pressure of CIP solutions for each phase of a cleaning cycle and automatically set the elapsed time, circulating temperature, and valve sequencing for the various cleaning operations. The punchcard programmers "CIP 40" and "CIP 41" electrically provide cleaning data for the "CIP Recorder Controllers." Pushbuttons underneath the programmers are for actuating the cleaning cycle when cleaning tank trucks or cold or hot milk lines. The punchcard file provides storage space for cards on which specific cleaning data for various items of equipment has been programmed. The "clean" switches are for cleaning tanks and vats. The switches are operated by inserting keys into them.

The CIP units may be used to clean through a closed circuit or an open circuit. A closed circuit is a system of pipelines joined together so that the solution feed pump provides the necessary pressure for circulating the solutions through the lines and back to the solution tanks. An open circuit is a system involving a tank or vat and necessitating a solution feed pump to move the solution to the tank or vat and a solution return pump.

Cleaning equipment parts contacting hot milk with an open circuit is illustrated by the operations performed in cleaning the buttermilk vat (24).

To clean the buttermilk vat the manhole cover is opened, a key taken from the cover mechanism, and the cover manually washed. The cover is left open during cleaning to prevent a vacuum forming in the vat and collapsing the walls. The key is then used at hookup station (54) to unlock the cap covering the line leading to the vat. When the cap is removed, a connection is made between the line leading to the CIP unit and the line to the vat. Figure 14 shows an isometric diagram of the piping that connects the CIP units (40 and 41), hookup stations (54), and solution return pumps (58), with the tank and vats cleaned by the CIP system.

A punchcard with the cleaning cycle programed on it for the buttermilk vat is removed from the punchcard file and inserted in the punchcard programmer (CIP 41) on the control panel. The key is then inserted in "Clean" switch No. 24 and turned to actuate the cleaning cycle of pre-rinse, alkali wash, rinse, acid wash, and rinse. The cycle requires about 1 hour. When the cleaning cycle is completed, the CIP unit automatically stops. The operator removes the punchcard from the programmer and places it in the punchcard file. To sanitize the vat the operator places a punchcard with the sanitizing program for the vat in the programmer, and turns the key in the switch again. The sanitizing period requires about 15 minutes. When the cycle is completed the unit is disconnected, the key is returned to the manhole cover, and the vat is closed.

Cleaning equipment parts contacting cold milk with an open circuit would be exactly the same as that described for cleaning the buttermilk vat, except the acid wash would be omitted.

Cleaning equipment parts contacting hot milk with a closed circuit is illustrated by the operations for cleaning the HTST System No. 1. In cleaning the system, a connection is made for CIP unit (41) at the hookup station. Hose jumpers would be used to bypass equipment items in the line that are cleaned manually. The punchcard for the HTST system with cleaning cycle programed on it is taken from the file and inserted into the programmer "CIP 41." The button just below the programmer is pushed to actuate the cleaning cycle. The cycle, including sanitizing, is the same as that described for the buttermilk vat.

Cleaning equipment parts contacting cold milk with a closed circuit would be the same as that described for cleaning the HTST System No. 1, except the acid wash would be omitted.

Other Operations

Other operations are those performed in connection with filling, casing, and stacking; storing cases in the cold room; loading out cases of milk and milk product; receiving, storing, and handling empty cases; and manual cleaning of equipment.

Filling, Casing, and Stacking

The filling machines automatically form, fill, and seal the cartons. A worker places carton blanks in the feed magazines as required.

From the discharge of the fillers the cartons are conveyed to automatic casers (29, 29A, and 29B) which place the proper number of cartons in each case. The automatic casers are kept supplied with empty cases by the automatic case dividers (39 and 39B).

From the casers the cases are conveyed to the automatic case-stackers (30, 30A, 30B), which

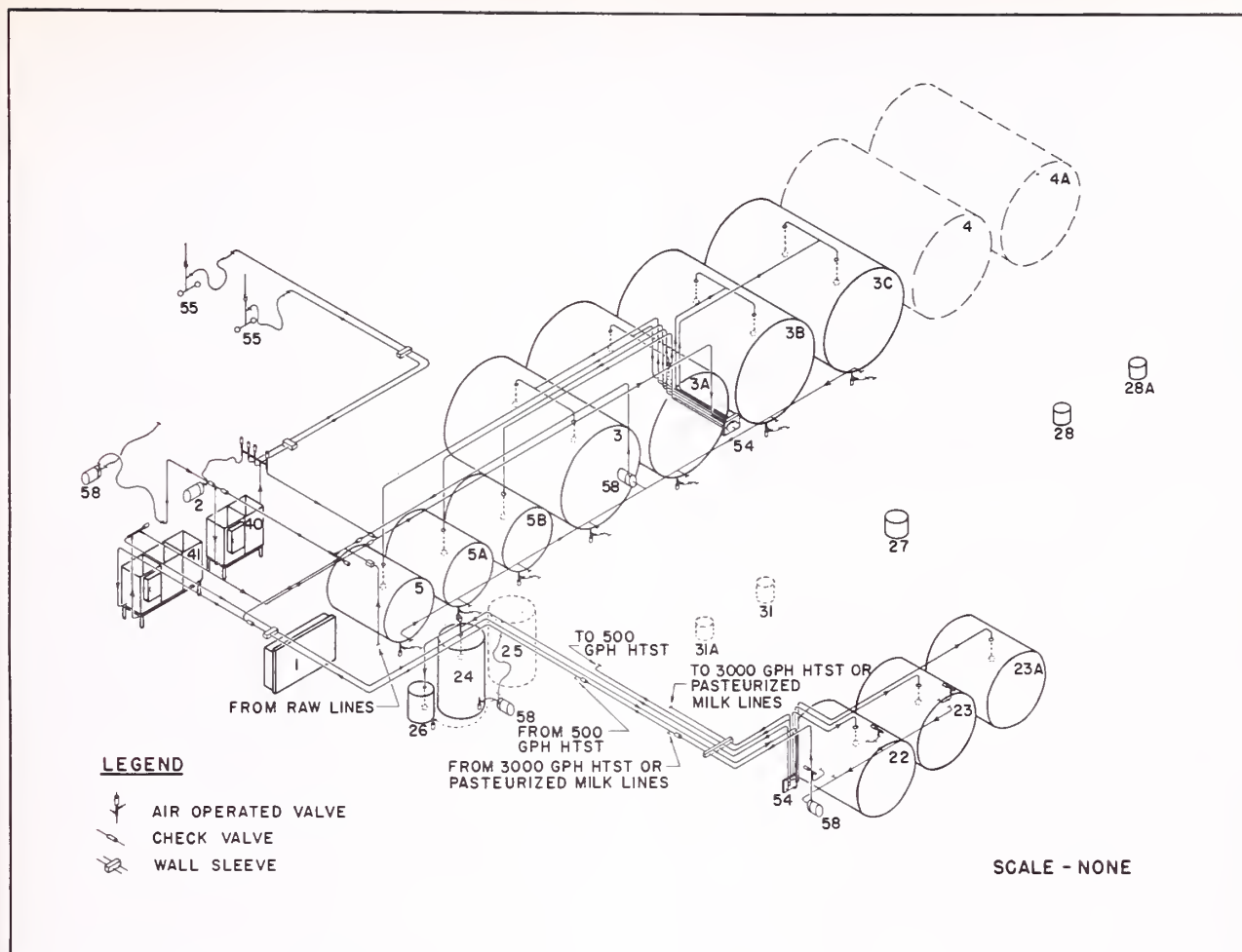


FIGURE 14.—A diagram showing piping for cleaned-in-place equipment in an automated multipurpose milk plant.

stack the cases five high (fig. 15). From this point the stacks are conveyed to the cold room.

Operators of the filling, casing, and stacking equipment perform five duties: (1) Start the automatic casers and case stackers; (2) obtain cartons from the container storage room; (3) keep magazines supplied with cartons; (4) make machine adjustments for changeover from one carton size to another; and (5) clear any jamming in the machinery caused by faulty cases or cartons. The operators are assisted from time to time by the worker in the cold room.

Storing Cases in the Cold Room

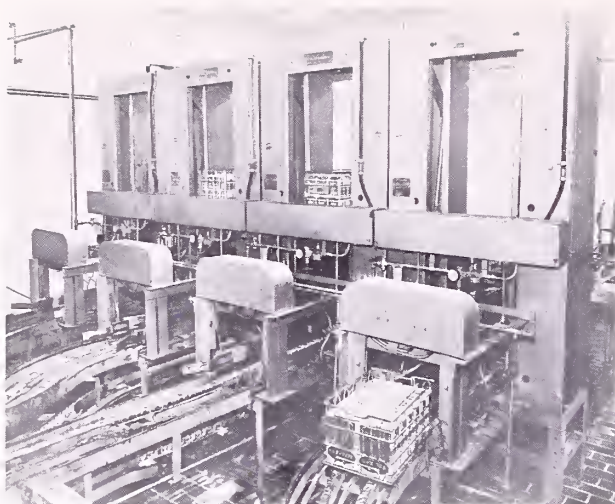
The stacks of cases are moved by the in-floor conveyor (34) to the cold room. Here a worker places a hook in the bottom case of the stack and drags it into its proper storage area, according to carton size and product. Since the plant operates 5 days a week and trucks are loaded on 6 days, the workers in the cold room must rotate the inventory so that the oldest product is loaded out first. Rotation occurs mainly during the after-

noon when trucks are loaded and two workers are in the cold room. On Thursday and Friday, when the cold room inventory is low, only a small amount of inventory is rotated. Two workers—one full-time and one part-time—store stacks of cases of milk and milk products in the cold room. The part-time worker also assists with the loading-out operations.

Loading Out Milk and Milk Products

A large part of the stacks of cases of milk and milk products entering the cold room after the first delivery trucks return to the plant are moved on the in-floor conveyor to the loading dock and loaded directly onto the trucks without being handled in the cold room.

A worker loads the stacks into the trucks according to the route sheet prepared in the main office. Since homogenized milk in quarts and half-gallons is loaded in stack lots only, no breaking down of stacks of these products is required. Byproducts are ordered by the drivers in case lots, thus the worker loading the trucks must occasion-



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FIGURE 15.—Automatic stackers for stacking cases of milk or milk products.

ally split these stacks at the time of loading. Two workers—one full-time and one part-time—perform the loading-out operations.

Receiving, Storing, and Handling Empty Cases

The drivers unload the empty cases in stacks upon returning to the plant from their routes. The stacks are dragged from the truck onto the in-floor conveyor (34) or into the storage area in the center of the loading dock.

The stack feed magazine (35) automatically feeds stacks of cases to the automatic case unstacker (36), thus freeing the worker for other duties, such as bringing paper supplies to the filler operator and handling cans. The stack feed magazine holds enough cases to supply the fillers for approximately 14 minutes when filler 27 is filling half-gallon cartons, filler 28A is filling quarts, and filler 28 is filling half-pints. A full-time worker and a part-time worker perform all the duties in connection with the receiving, storing, and handling of empty cases.

Manual Cleaning of Equipment

Machines which require manual cleaning are the cold milk separator (10), clarifier (9), positive displacement timing pumps (13, 13A), homogenizers (17, 19), bowls on fillers (27, 28, 28A), balance tanks (11, 11A), the line connecting the flow diversion valves and the balance tanks, and the flow diversion valves. These machines are disassembled and the parts placed in one of the cleaned-out-of-place (COP) portable washers (42). These units clean by circulating heated cleaning solutions around the disassembled parts. After cleaning, the parts are rinsed with fresh water and allowed to dry. Machines are reassembled the next day.

The cleaning of this equipment usually takes place while the circuit in which the piece of equipment is used is being cleaned automatically. Practically all plant workers participate part-time in these operations.

Labor Requirements

Fifteen workers, other than the office crew and route truck drivers, would be required to operate the automated plant. This is nine fewer workers than would be required to operate a nonautomated plant handling a similar volume. The reduction in the number of workers required in the automated plant is due to the use of automated and mechanized equipment which requires fewer workers or permits workers to perform additional duties.

The crew for the automated plant consists of a supervisor (production superintendent), 2 maintenance workers, who also operate the refrigeration and heating systems, a relief worker, a laboratory technician and 10 other workers. The 10 other workers and the relief worker would perform the basic operations of receiving, processing, packaging, and storing milk; cleaning; and receiving and handling empty cases, cartons, and dry supplies. The crew for the nonautomated plant would consist of 24 workers—a supervisor, a maintenance worker, 2 relief workers, a laboratory technician and 19 other workers. The 19 other workers and the 2 relief workers would perform the basic operations in the nonautomated plant.

The supervisor in an automated or nonautomated plant would supervise all the activities pertaining to the basic operations and maintain records pertinent to production. The hours of duty for the supervisor would be from about 8 a.m. to 5 p.m. in both types of plants. Maintenance of the highly mechanized and automated equipment in the automated plant and operation of the refrigeration and heating systems require two maintenance workers; one maintenance worker is needed in a nonautomated plant. Only one relief worker would be required by the automated plant, compared with two for the nonautomated plant. Relief workers fill in for absentees, relieve other workers for rest periods, and fill in for workers on vacation. In the automated plant, rest or lunch periods in some instances can be arranged to correspond with the times when the machines are doing the work.

Three workers would be required to receive, grade, separate, standardize, pasteurize, and homogenize milk and milk products in an automated plant; five workers would be needed in a nonautomated plant. This reduction is due almost solely to the use of automated equipment. The operations would be carried on in both types of plants

from about 5 a.m. to 4 p.m., and the shifts for workers would be staggered.

Two full-time workers and one part-time worker would be required to perform the packaging, casing, and case-stacking operations in the automated plant, compared with six workers in the nonautomated plant. Automatic casers and case stackers are responsible for this reduction. These operations would be performed in both the automated and nonautomated plants from about 6 a.m. to 7 p.m., and the shifts of the workers would be staggered.

Cold room operations—dragging stacks of cases from the conveyor to storage point and from storage point back onto the conveyor and loading trucks—would require two full-time workers and a part-time worker in an automated plant, compared with five workers in a nonautomated plant. The reduction in the number of workers in the automated plant is due to the use of automatic case stackers and an in-floor conveyor. In an automated plant cases would be handled in stacks of five; in a nonautomated plant they would be handled singly. The shifts for workers would be staggered in both types of plants. The duties would be performed between 7:30 a.m. and 9 p.m.

Operations in the empty-case storage room in both types of plants would be performed from about 7:30 a.m. to 6 p.m. A full-time worker and a part-time worker would perform these operations in the automated plant; two full-time workers and one part-time worker would be needed in a nonautomated plant. The reduction in the labor requirements is due to the use of a stack feed magazine, an automatic case unstacker, automatic case dividers, and an in-floor conveyor in the empty-case storage room and on the truck dock.

Dry storage room and paper-container storage room operations in both types of plants would be performed periodically by a part-time worker. Although no labor savings are estimated for this work, the work should be easier and require less time for the worker in the automated plant to perform because the arrangement of components should result in shorter distances to transport carton blanks and other supplies.

In an automated plant, much of the equipment is cleaned automatically; 11 workers devote part of their time to cleaning of other equipment and of work areas, compared with 20 workers in a nonautomated plant.

Plant Handling 35,000 Gallons of Milk Weekly

The objectives in developing principles and criteria for the use of dairy plant operators in planning new or remodeling old multipurpose milk plants with automated methods for a plant handling 35,000 gallons of milk weekly are the same as those listed for the larger plant.

Costs and Possible Benefits of Labor-Saving Devices

The equipment required for the automated plant to minimize labor requirements would consist of a control panel (1); remotely controlled sanitary valves and load cells; automated CIP units (40 and 41); two CIP washers (55) for cleaning transport tanks; automatic casers (29, 29A, and 29B); automatic case stackers (30, 30A, and 30B); automatic case unstacker (36); feed stack magazine (35); in-floor conveyor (34); automatic case dividers (39 and 39A); and automatic case inverter (37). It is estimated that the cost of the equipment would be \$146,000 greater than that for a nonautomated plant.

It is estimated that the automated multipurpose milk plant handling 105,000 gallons weekly could operate with at least nine fewer workers than a properly arranged and operated nonautomated multipurpose plant handling a similar volume. Based on an assumed cost of \$6,500 annually per worker (salary plus fringe benefits), the annual savings in labor would amount to \$58,500 for an automated plant. If 20 percent is allowed annually for ownership and operating costs (depreciation, maintenance, insurance, taxes, and interest), the costs would amount to \$29,200, and an annual savings of \$29,300 would result. The savings would amortize the cost of the equipment in about 5 years.

Production per man-hour of labor should be higher in the automated plant than in the nonautomated plant. It is estimated that on a peak production day (22,500 gallons) the production in the automated plant would be about 176 gallons per man-hour, compared with 117 gallons per man-hour in a nonautomated plant. Based on handling 105,000 gallons weekly, the production per man-hour is 175 gallons for the automated plant and 109 gallons for the nonautomated plant. Roughly, the production per man-hour is 60 percent greater for the automated plant than for a nonautomated plant.

Machine-controlled operations should result in reduction in in-plant losses of milk. They also should provide for more stable standards than are obtained in a nonautomated plant using conventional equipment. No data are available for the savings that would be realized from these two items.

Assumptions With Respect to Plant Operations

The assumptions used with respect to plant operations for this plant are the same as those listed for the larger plant.

The assumed inventory and processing schedule for the plant handling 35,000 gallons weekly is shown in table 3. Raw milk would be received 7 days a week; however, milk would be processed only 5 days a week. Raw milk would be received from local producers every day in the week and from milk marketing associations on Tuesday, Friday, and Saturday. The plant would do no processing on Wednesday and Sunday.

Practically the same amount of finished product (5,830 gallons) would be sold 6 days a week—Monday through Saturday. Since the plant would process only 5 days a week, the plant should have sufficient capacity to process enough products on Monday and Tuesday, plus the carryover,

to handle Wednesday's and Thursday's sales. The amount of milk and milk products processed on Monday, the peak day, is 7,650 gallons.

Chocolate drink would be made in the plant only on Monday, Thursday, and Saturday, and coffee cream would be made only on Tuesday and Friday. This schedule would simplify processing; it would reduce the number of changeovers from one product to another on any given day.

The plant would operate on a butterfat shortage; thus it would purchase 40-percent cream on Tuesday and Friday to make coffee cream. The cream would be received in 10-gallon cans, since the small quantity needed would not lend itself to bulk handling.

TABLE 3.—*An assumed inventory and processing schedule for a plant handling 35,000 gallons of milk weekly*

Milk inventory	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>
Beginning raw milk inventory	4,000	350	0	4,000	1,330	1,330	0
Raw milk receipts ¹	4,000	7,000	4,000	4,000	6,670	5,340	4,000
Total	8,000	7,350	4,000	8,000	8,000	6,670	4,000
Processed milk:							
Market milk	6,000	6,000	0	5,330	5,330	5,330	0
Half-and-half	450	450	0	400	400	400	0
Buttermilk	600	600	0	540	540	540	0
Chocolate drink	600	0	0	400	0	400	0
Coffee cream	0	300	0	0	400	0	0
Total	7,650	7,350	0	6,670	6,670	6,670	0
Raw milk holdover	350	0	4,000	1,330	1,330	0	4,000
Finished product sales	5,830	5,830	5,830	5,830	5,830	5,850	0
Finished product holdover ²	10,140	11,660	5,830	6,670	7,510	8,320	8,320

¹ Milk received from milk marketing associations by days: Tuesday, 3,000 gallons; Friday, 2,670 gallons; and Saturday, 1,340 gallons. The rest of the milk is received from local producers.

² Finished product holdover includes products held over in both the cold room and refrigerated delivery trucks.

The plant would operate during daytime hours. The plant would make wholesale deliveries only, and trucks would be loaded between 1 p.m. and 4 p.m. for the next day's delivery. Thus, 5,830 gallons of milk and milk products would be stored on trucks 5 days during the week and 5,850 gallons on 1 day. The finished product holdover shown on the inventory and processing schedule includes finished products stored both in the cold room and on trucks. The peak period for storage of finished products in the cold room would be on Tuesday at about 1 p.m.; about 11,660 gallons would be in the cold room at this time.

The number of containers by size and content required for the peak production day of 7,650 gallons is shown in table 4.

Suggested Layout of the Plant

The suggested layout of the plant handling 35,000 gallons of milk weekly is shown in figure

16. The basic principles observed in arranging the various components are the same as those for the larger plant.

The suggested plant is irregular in shape. Roughly, its depth is 190 feet and its width at the widest point is 144 feet. It provides approximately 13,400 square feet of space.

Components of the Facility

The major components for the plant handling 35,000 gallons of milk weekly are similar to those listed for the larger plant. Figure 16 shows the arrangement of the components in a plant layout and the arrangement of each item of equipment suggested for each component. Each item of equipment on the layout is numbered and is referred to by number in the discussion of the components. Principles used in designing the components are the same as those used for the larger plant; construction features would be the same.

LEGEND

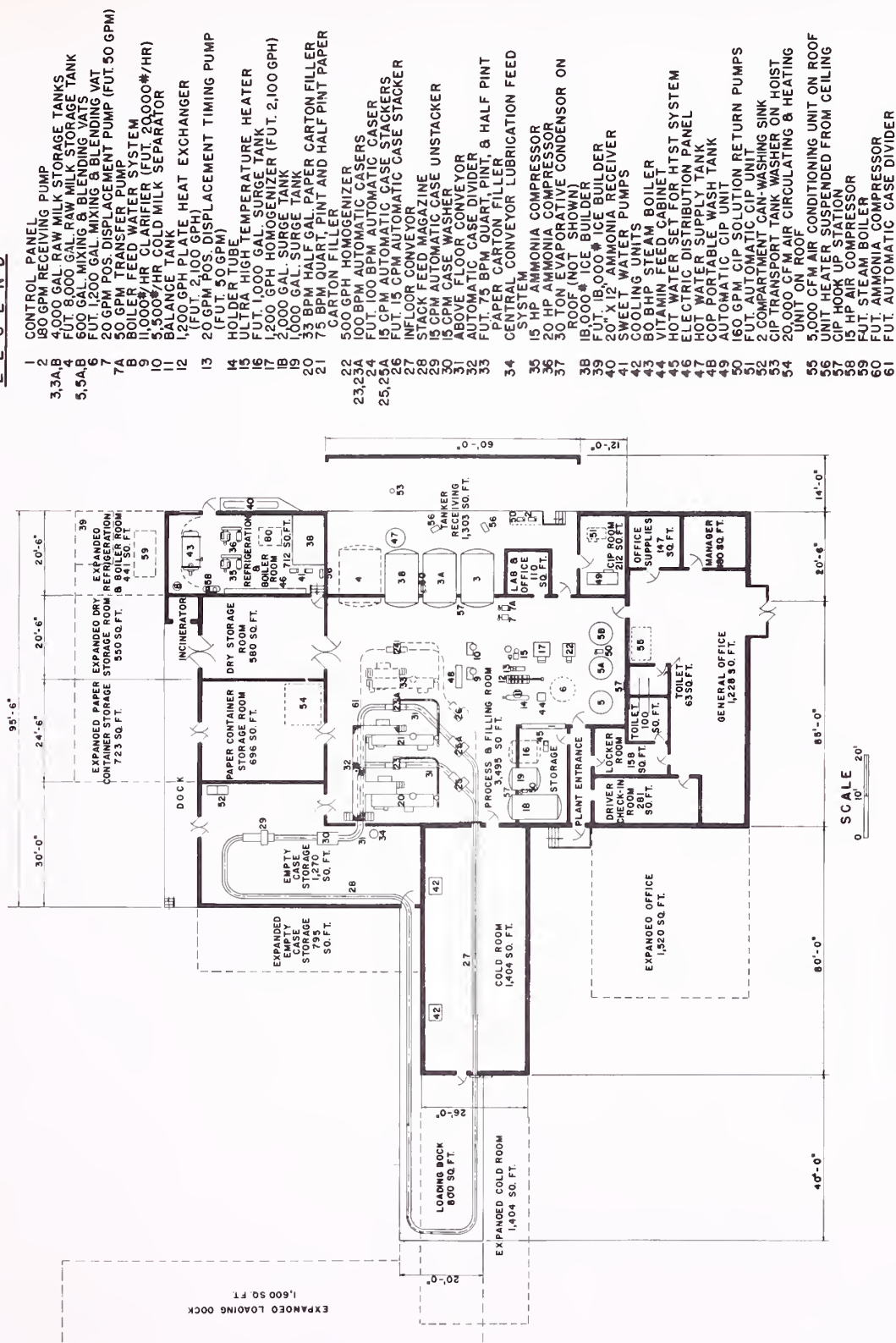


FIGURE 16.—A suggested layout for an automated multipurpose milk plant handling 35,000 gallons of milk and milk products weekly.

TABLE 4.—Assumed number of containers, by size and content, for a peak day of 7,650 gallons in a plant processing 35,000 gallons of milk weekly

Product	Container size				Total
	Half gallon	Quart	Pint	Half pint	
Market milk.....	7, 200	7, 200	4, 800	0	19, 200
Buttermilk.....	0	1, 600	0	3, 200	4, 800
Half-and-half.....	0	0	3, 600	0	3, 600
Chocolate drink.....	0	800	0	6, 400	7, 200
Coffee cream ¹	0	0	0	0	0
Total.....	7, 200	9, 600	8, 400	9, 600	34, 800

¹ Coffee cream would not be made on the peak volume day.

Tanker-Receiving Shelter

The tanker-receiving shelter suggested is of the drive-through type. It is 59¼ feet long and 22 feet wide. The shelter will accommodate one truck at a time, which should be adequate for a plant receiving only 7,000 gallons of raw milk on its peak volume day.

A platform 8 feet wide next to the plant proper, runs the full length of the shelter. A receiving pump (2) with a capacity of 180 gallons per minute and a CIP solution return pump (50) are located under the platform. A hot water supply tank (47), used to provide hot water for general plant cleaning, is located on the platform.

The driveway is 14 feet wide. It should be equipped with a CIP transport tank washer (53) mounted on a hoist. The length of the shelter provides ample space for a truck to unload and then drive up to the wash station.

Raw-Milk Storage Area

The suggested raw-milk storage tank area is 12 feet wide and 42 feet long. It provides space for three 4,000-gallon raw-milk storage tanks (3, 3A, and 3B) and for a future 8,000-gallon raw-milk storage tank (4) in case plant volume is expanded. The head of each tank is inside the processing and filling room; the main body of the tank is outside in an area contiguous to the dock of the receiving shelter. No rear wall is necessary to enclose the tanks.

The tanks would be equipped in the same manner as those described for the larger plant. These tanks would be connected to a three-line header system. One line is for transferring raw milk from truck tanks to storage tanks and skim milk from the cold milk separator to the storage tanks; the second is for transferring milk from the storage tanks to the cold milk separator or the mixing and blending and buttermilk vats; and the third is for transferring standardized milk from the storage tanks to the HTST system. All three lines may be used at the same time.

A CIP solution return pump (50) is located between tanks 3A and 3B.

Processing and Filling Room

The processing and filling room contains 3,495 square feet. The room provides space for the control panel, processing equipment, and the filling, casing, and stacking equipment.

The control panel is similar to the one described for the larger plant. It is 4 feet 8 inches high and 11 feet long.

PROCESSING EQUIPMENT.—The processing equipment would consist of a centrifugal transfer pump (7A) with a capacity of 50 gallons per minute; a cold milk separator (10) with a capacity of 5,500 pounds per hour; three 600-gallon mixing and blending vats (5, 5A, and 5B); a homogenizer (22) with a capacity of 500 gallons per hour; a 2,000-gallon surge tank (18); a 1,000-gallon surge tank (19); and an HTST system. This system would consist of an HTST feed pump (7) with a capacity of 1,200 gallons per hour; a clarifier (9) with a capacity of 11,000 pounds per hour; a balance tank (11); a plate heat exchanger (12) with a capacity of 1,200 gallons per hour; a holder tube (14); a vitamin feed cabinet (44); a positive displacement timing pump (13) with a capacity of 1,200 gallons per hour; an ultra-high-temperature heater (15); and a homogenizer (17) with a capacity of 1,200 gallons per hour.

Centrifugal transfer pump 7A is used to pump milk from the raw-milk storage tanks into the separator, to transfer skim milk between storage tanks and skim and raw milk from the storage tanks to the mixing and blending vats.

The three mixing and blending vats are used for the preparation and pasteurization of buttermilk, coffee cream, half-and-half, and chocolate drink. They are equipped with agitators, spray balls, and steam jackets, and have refrigerated surfaces.

The small homogenizer (22) is used to homogenize byproducts.

The HTST system is used in the pasteurization and homogenization of market milk; its functions are the same as those described for HTST system No. 1 of the larger plant.

The separator and surge tanks function in the same manner as that described for the larger plant.

FILLING, CASING, AND STACKING EQUIPMENT.—The filling, casing, and stacking equipment suggested consists of a half-gallon filler (20) with a capacity of 33 b.p.m. (cartons per minute); a quart, pint, and half-pint filler (21) with a capacity of 75 b.p.m.; two automatic casers (23 and 23A) with a capacity of 100 b.p.m. each; two automatic case stackers (25 and 25A) with a capacity of 15 c.p.m. (cases per minute) each; an automatic case divider (32); an above-floor conveyor system (31); and an in-floor conveyor (27).

The half-gallon filler (20), automatic caser (23), and automatic case stacker (25) would be used only to package market milk. The quart, pint, and half-pint filler (21), caser (23A), and case stacker (25A) would be used for quarts, pints, and half-pints of market milk and byproducts.

CLEANING-OUT-OF-PLACE EQUIPMENT.—A cleaning-out-of-place recirculating washer (48) is located in the processing and filling room for cleaning machinery which must be partially dismantled for cleaning.

Cold Room

In-floor conveyor (27) extends from the processing and filling room through the cold room to the truck dock.

The maximum amount of milk which would be stored in the cold room, assuming that loading out would begin at 1 p.m., is about 11,660 gallons of milk and milk products. Based on the ratio of container sizes previously stated, this would amount to 2,915 cases. Stacking cases 5 high would make it necessary to provide space for storing 583 stacks.

Based on a space allowance of 1.36 square feet per stack, and an allowance of 30 percent for the in-floor conveyor (27) and aisle space, 1,133 square feet of space would be needed. A room 24 feet wide and 58½ feet long is suggested. The extra space provided in the room allows for storing cream received at the plant in cans. The extra space also gives some leeway in the amount of milk and milk products that could be stored in the cold room, in case loading of trucks does not begin promptly at 1 p.m.

Truck Dock

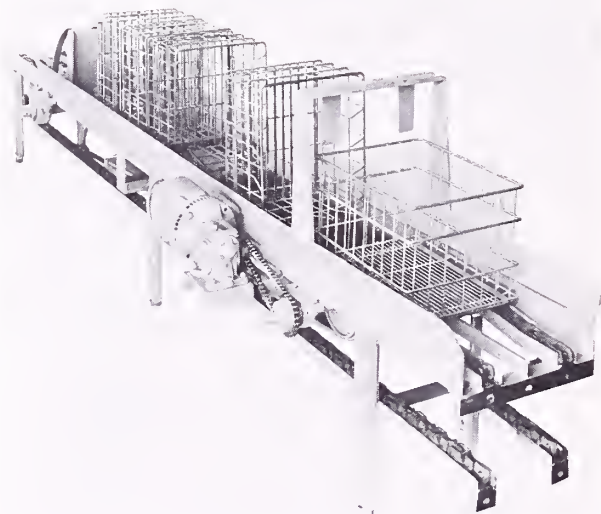
The truck dock suggested for loading milk and milk products onto wholesale delivery trucks, for unloading empty cases from trucks, and for storing empty cases is 20 feet wide and 40 feet long. It is equipped with an in-floor conveyor (27) that leads from the cold room and runs into the empty-case storage room. Cases would be stored in an area about 14 feet wide and 32 feet long. If 20 percent is allowed for aisle space, this area would provide storage for about 263 stacks of empty cases. The dock provides space for eight trucks to

load simultaneously. The dock should be equipped with electric plug-in lines to provide power to operate mechanical refrigeration equipment in the trucks.

Storage Rooms

Separate rooms are provided for storing empty cases, paper containers, and miscellaneous dry supplies. The equipment suggested for the empty-case storage room consists of a stack feed magazine (28) that holds 200 cases in stacks 5 high; a 15-c.p.m. automatic case unstacker (29) (fig. 17); a 15-c.p.m. case washer (30); an above-floor conveyor (31); a supply tank (34) for conveyor lubricant; and a double sink for washing cans (52). The in-floor conveyor (27) continues into this room from the truck dock.

The number of empty cases to be stored would be approximately equal to the number of cases used for storing milk in the cold room during the peak storage period—2,915 cases or 583 stacks of 5 cases each. As previously noted, the truck dock would provide space for storing about 263 stacks of empty cases. Thus, the empty-case storage room would need to provide space for about 320 stacks.



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FIGURE 17.—An automatic unstacker for unstacking empty cases.

An empty-case storage room containing about 1,270 square feet of space is suggested for storing 320 stacks of empty cases, for housing equipment, and to provide adequate aisle and working space. A small amount of extra space is provided in the room to give some flexibility in storing cases.

A room 24 feet wide by 29 feet deep is suggested for storing cartons. It would provide space for storing about 56 pallets of cartons in the ratio of sizes given herein. The space provided is in excess

of the actual space needed, which is for about 39 pallets. However, the extra space suggested would provide the plant some flexibility in its inventory and purchasing policy.

A dry storage room 20 feet wide and 29 feet deep is suggested for storing miscellaneous supplies.

Laboratory and Plant Superintendent's Office

The laboratory and plant superintendent's office are combined into one room for this plant. A room 11 feet wide and 10 feet deep is suggested.

Boiler and Refrigeration Equipment Room

One room would be used for housing the boiler and refrigeration equipment for the plant. The room suggested is 19½ feet wide and 37 feet in length. (See appendix for further information on the refrigeration, heating, and ventilation systems.)

Cleaned-in-Place Equipment Room

A room 11 feet wide and 19½ feet in length is suggested for an automatic cleaned-in-place unit (49). The unit would have three solution tanks (a rinse, an alkali, and an acid).

In addition to these units, the cleaned-in-place system for the plant would consist of four solution return pumps (50), two hookup stations (57), and one transport washer (53) located in other parts of the plant.

The CIP units are wired to the "CIP Recorder Controllers" and the punchcard programmer "CIP 49" on the control panel.

Main Office Areas

The main office areas include the general office, manager's office, office supply room, and drivers' check-in and locker rooms. The general office contains 1,228 square feet; the manager's office, 180 square feet; the office supply room, 147 square feet; the drivers' check-in room, 281 square feet; and the locker room, 158 square feet.

Provisions for Plant Expansion

The layout for the multipurpose milk plant handling 35,000 gallons per week provides for future expansion to 70,000 gallons. In some instances the expansion would necessitate the addition of more plant area, and in others the expansion would be made by adding more equipment or by exchanging present equipment for equipment with a greater capacity. Part of the expansion would necessitate adding both plant area and equipment. The expansion could also be made with present facilities and equipment by operating two shifts. However, for the purpose of this report, it is assumed that all operations would be performed on one shift. The components of the plant which would require more area for the plant to handle 70,000 gallons a week efficiently are the boiler-refrigeration room, empty-case storage

room, cold room, container storage room, dry storage room, loading dock, and main office.

A total of 7,033 square feet would need to be added for the plant to handle 70,000 gallons weekly. This is about 52 percent more floor space than the suggested plant contains. Excluding the area suggested for office and entrance space expansion, the plant capacity could be doubled by adding 5,513 square feet, or 41 percent more space.

An area 20½ feet wide and 21½ feet long would be added to the boiler-refrigeration room. This addition could be made by removing one exterior wall of the present boiler room.

The empty-case storage room would require an addition 15 feet wide and 53 feet long. The addition could be made by the removal of one exterior wall.

The truck dock for loading cases of milk and unloading empty cases could be extended 80 feet. The total truck dock space would provide space for 16 trucks.

The cold room would require an addition 26 feet wide and 60 feet deep, or 1,404 square feet of usable space, doubling the size of the present room. An area containing 723 square feet of space would be added to the container storage room. This space requirement could be minimized by having more frequent deliveries of empty cartons. An area containing about 550 square feet would be added to the dry storage room.

The main office would be increased by 1,520 square feet. Although the office expansion shown on the layout is on the ground floor, the possibility of adding needed space above the present office should be considered.

The raw-milk storage tank room was originally designed to provide space for an additional tank, and as a result, an 8,000-gallon raw-milk storage tank (4) can be added with a minimum of remodeling and without enlarging the room.

The processing and filling room was also designed to provide space for either larger or additional equipment required if the plant volume increased from 35,000 to 70,000 gallons weekly. The present control panel is adequate and would require only the wiring of the new processing and filling equipment controls into the circuits provided for future equipment on the panel. To convert the processing equipment to handle the increased volume the equipment changes or additions are as follows: The HTST system would require that the holder tube (14) and the plate heat exchanger (12) be enlarged to handle 2,100 g.p.h. (gallons per hour); the replacement of the 1,200 g.p.h. homogenizer (17) with a 2,100-g.p.h. machine; the replacement of the 11,000-p.p.h. (pounds per hour) clarifier (9) with a 20,000-p.p.h. clarifier; and the addition of a 1,200-gallon mixing and blending vat (6).

The following would be added to the filling equipment to handle the increased product flow: A 1,000-gallon pasteurized milk surge tank (16);

a 75 b.p.m. (cartons per minute) quart to half-pint filler (33), a 100-b.p.m. automatic caser (24), a 15-c.p.m. automatic case stacker (26), and an automatic case divider (61).

Expansion of the boiler-refrigeration room, plus extra space allowed in the original design, provides space for an additional steam boiler (59) and an 18,000-pound ice builder (39). Space is also provided for a compressor (60) of a size needed to handle the additional refrigeration requirements.

The CIP room was originally designed to provide space for an additional automatic CIP unit (51). The controls for this unit should be in the CIP room since it is suggested that the added unit be used for tank truck cleaning only.

Plant Site

The layout of the site for the suggested plant handling 35,000 gallons of milk weekly is shown in figure 18. The plant is located on a site 330 feet wide and 360 feet deep which contains about 2.7

acres. The plant proper contains about 13,400 square feet and is located to one side and toward the front of the site. It is suggested that four areas, one directly in front and adjacent to the main office building, and three along the front of the site, comprising about 17,500 square feet, be landscaped.

The garage suggested for the plant is a separate building on the plant site. The garage is 50 feet by 34 feet, and contains 1,617 square feet of usable space.

Two paved driveways connecting the plant with a highway are suggested. The driveways would be about 40 feet wide.

Well-defined parking areas should be provided on the site for 38 motor vehicles. These areas should be out of the traffic lanes but easily accessible from them. The parking spaces should be paved and well drained. Individual spaces for 30 automobiles should be 11½ feet wide and 20 feet deep, and for 8 trucks 10 feet wide and 25 feet deep. All truck spaces should be equipped with

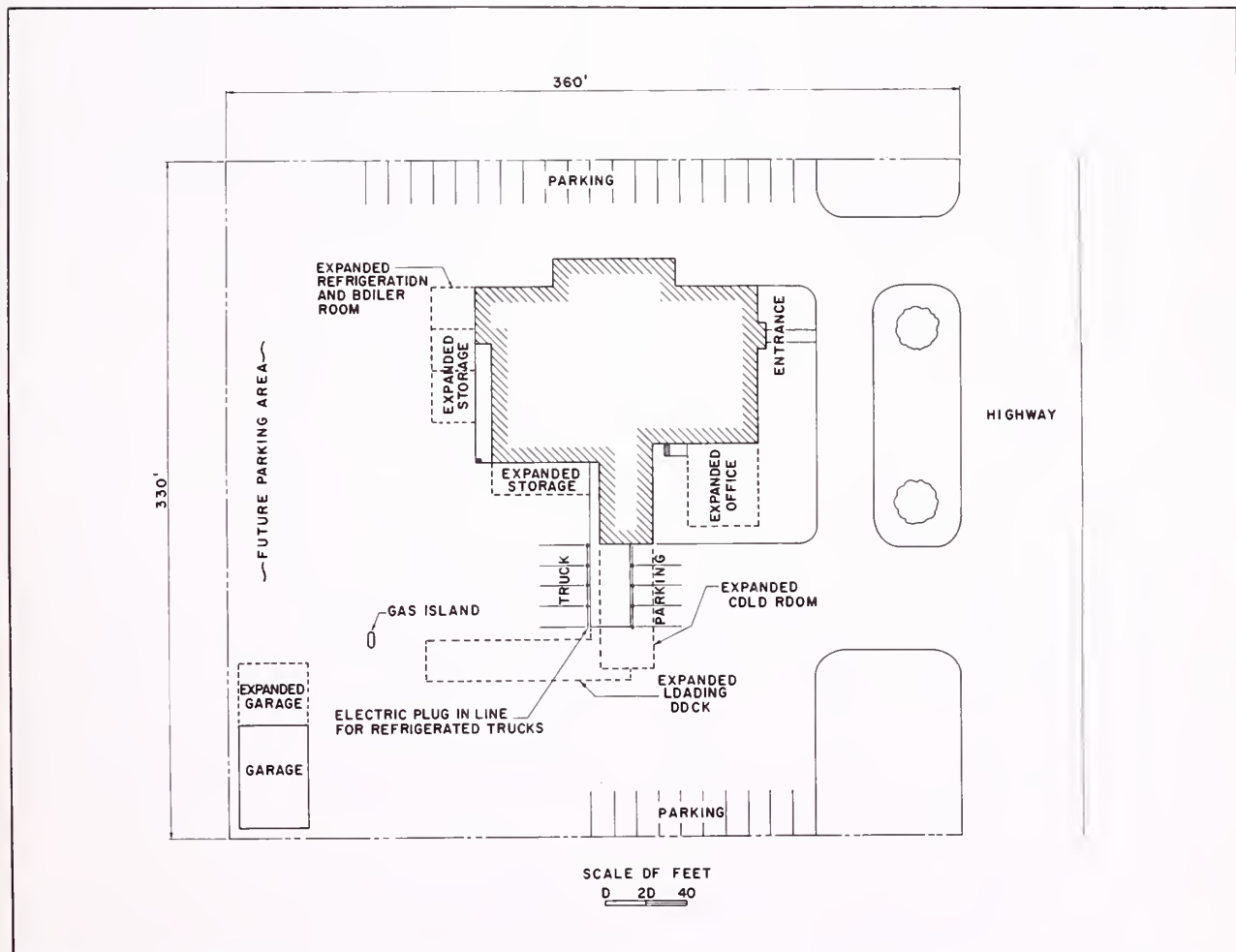


FIGURE 18.—A suggested layout of the site for an automated multipurpose milk plant handling 35,000 gallons of milk and milk products weekly.

electric plug-in lines to provide electrical power to operate the mechanical refrigeration equipment in each truck. A gas island should be located to the rear of the site near the garage.

Equipment Use Schedule

The schedule of equipment use (fig. 19) for the peak processing day of the week shows the time periods necessary for receiving, separating, standardizing, pasteurizing and homogenizing, and filling cartons. In addition to the periods shown for the cleaning equipment, filling machines must be cleaned after they have been used for buttermilk or chocolate drink. On the peak day 6,000 gallons of market milk, 600 gallons of buttermilk, 450 gallons of half-and-half, and 600 gallons of chocolate drink are processed. Coffee cream is not processed on the peak volume day.

Receiving Raw Milk

The equipment used in receiving raw milk consists of storage tanks (3, 3A, or 3B) and receiving pump (2). The letter A on the bar beside the tank indicates the time period the equipment is used in receiving milk on a peak volume day.

Receiving of raw milk would begin about 6 a.m. and continue intermittently until about 8 a.m. About 4,000 gallons would be received in tank 3A. Pump 2 would be used to receive the milk. The letter O indicates the time milk with a butterfat content of 3.8 percent is held in the storage tanks when no operations are being performed.

Separating

The equipment used in separating raw milk consists of a storage tank (3), pump (7A), and separator (10). The letter B indicates the time period this equipment is in use in separating milk. The mixing and blending vat (5A) is used to receive the separated 12-percent fat product, and the storage tank (3B) is used to receive the separated 0.1-percent skim milk. The letters D and C are used to indicate the time periods these items of equipment are receiving separated products.

At the beginning of the day about 1,500 gallons of the 4,000 gallons of milk with a butterfat content of 3.8 percent held over from the previous day in tank 3 would be separated. Separation would begin about 5:30 a.m., and continue to about 7:50 a.m. The skim milk would be diverted to tank 3B for standardizing and the 12-percent fat product would be diverted to mixing and blending vat 5A for making half-and-half. The letters Q and R indicate the time periods that skim milk and the 12-percent fat product are held in the tanks with no operation taking place.

Standardizing

MARKET MILK.—The equipment used in standardizing market milk consists of storage tanks

(3, 3A, and 3B) and pump (7A). The time periods the equipment is in use are indicated by the letter E. Standardizing raw milk with a butterfat content of 3.8 percent to 3.5 percent butterfat would be performed by pumping skim milk from tank 3B to the raw milk in tanks 3 and 3A using pump 7A. Standardization would require about 15 minutes for each tank. Although about 6,350 gallons of market milk would be standardized, only 6,000 gallons would be needed; so, theoretically, about 350 gallons of standardized milk would remain in tank 3A. (From a practical operating standpoint, these 350 gallons also would be processed.) The letter P indicates the time periods market milk would be held in the various storage tanks.

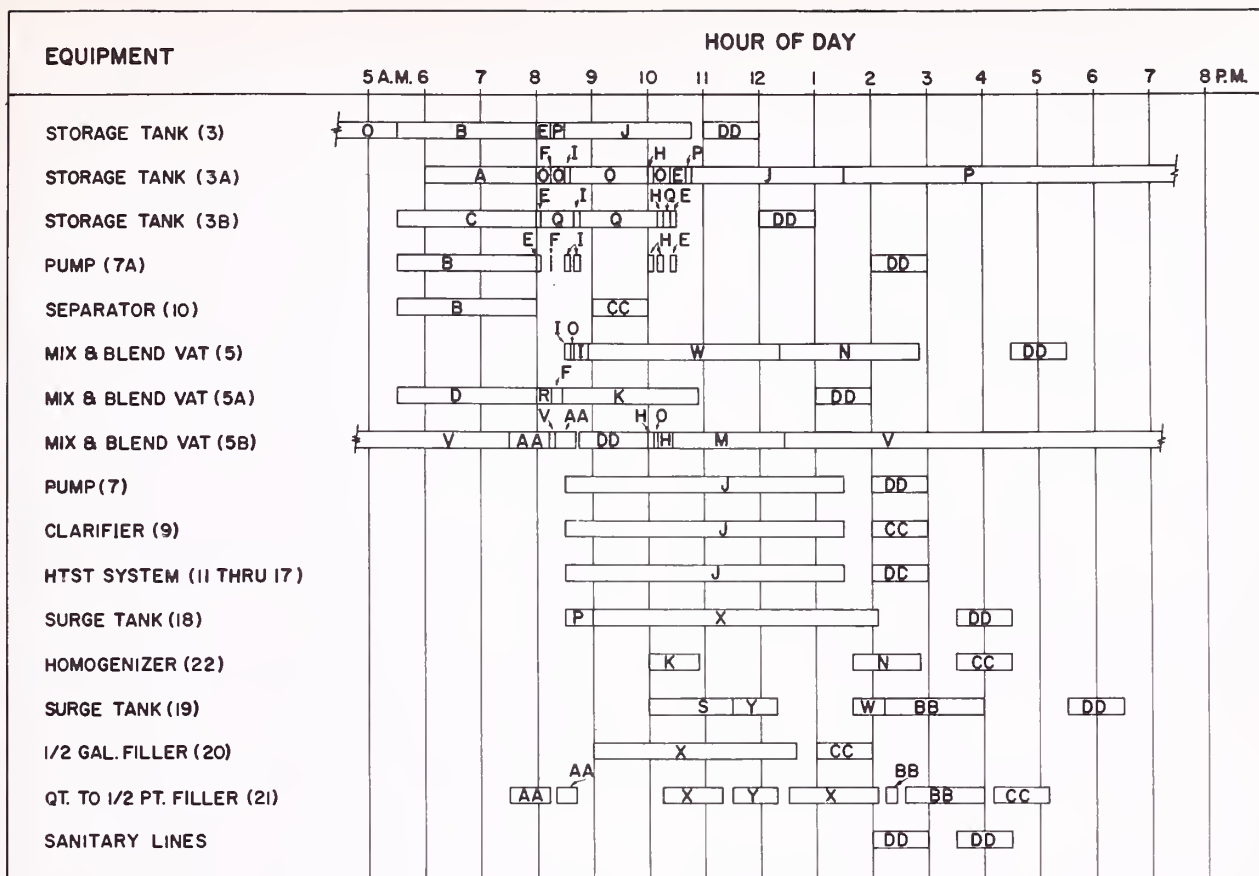
HALF-AND-HALF.—The equipment used in standardizing half-and-half consists of storage tank (3A), pump (7A), and mixing and blending vat (5A). The letter F indicates the time the equipment is in use. About 400 gallons of 12-percent fat product in mixing and blending vat (5A) would be standardized to about 450 gallons of 11-percent half-and-half between 8:15 a.m. and 8:30 a.m. Pump 7A is used to transfer 3.8 percent raw milk from tank 3A to vat 5A.

CHOCOLATE DRINK.—Standardizing 3.8-percent raw milk and 0.1-percent skim milk into a 2-percent butterfat product to be made into 600 gallons of chocolate drink would be performed by pumping raw milk from tank 3A and skim milk from tank 3B into mixing and blending vat 5. This standardization begins about 8:30 a.m. and is completed about 8:55 a.m.; the standardized milk is held in the vat until about 12:10 p.m. for processing. Pump 7A is used to transfer the raw milk and skim milk to the chocolate drink vat. Chocolate syrup is manually added to vat 5 during standardization. The letter I indicates the time the equipment is in use and the letter W indicates the time chocolate drink is held in vat 5 when no operation is being performed.

BUTTERMILK.—Standardizing 3.8-percent raw milk and 0.1-percent skim milk into a 2-percent butterfat product to be made into 600 gallons of buttermilk would be performed by pumping 3.8-percent raw milk from tank 3A and skim milk from tank 3B into mixing and blending vat 5B. This standardization begins about 10 a.m. and is completed about 10:25 a.m. Pump 7A is used to transfer 3.8-percent raw milk and 0.1-percent skim milk to the buttermilk vat. The time the equipment is in use is designated by the letter H.

Pasteurizing and Homogenizing

MARKET MILK.—The equipment used in the pasteurization and homogenization consists of storage tanks (3 and 3A), pump (7), clarifier (9), and the HTST system. The letter J indicates the time period the equipment is in use.



LEGEND

A. RECEIVE 3.8 % MILK	K. PROCESS HALF & HALF	U. HOLD 20% COFFEE CREAM
B. SEPARATE 3.8% MILK	L. PROCESS COFFEE CREAM	V. HOLD 2.0 % BUTTERMILK
C. SEPARATED 0.1% SKIM	M. PROCESS BUTTERMILK	W. HOLD 2.0% CHOCOLATE DRINK
D. SEPARATED 12% FAT PRODUCT	N. PROCESS CHOCOLATE DRINK	X. FILL 3.5% MILK
E. STANDARDIZE FOR 3.5% MILK	O. HOLD 3.8 % MILK	Y. FILL 11% HALF & HALF
F. STANDARDIZE FOR 11% HALF & HALF	P. HOLD 3.5 % MILK	Z. FILL 20% COFFEE CREAM
G. STANDARDIZE FOR 20% COFFEE CREAM	Q. HOLD 0.1% SKIM	AA. FILL 2.0% BUTTERMILK
H. STANDARDIZE FOR 2.0% BUTTERMILK	R. HOLD 12% FAT PRODUCT	BB. FILL 2.0% CHOCOLATE DRINK
I. STANDARDIZE FOR 2.0% CHOC. DRINK	S. HOLD 11% HALF & HALF	CC. CLEAN EQUIPMENT (MANUAL)
J. PROCESS MARKET MILK	T. HOLD 40% CREAM	DD. CLEAN EQUIPMENT (CIP)

FIGURE 19.—Assumed equipment use schedule for processing 7,650 gallons of milk on a peak day. Although not shown in the schedule, machines used for buttermilk or chocolate drink must be cleaned before they are used for other products.

Processing of market milk would begin about 8:30 a.m. and continue until approximately 1:30 p.m.—a total of 5 hours. Tank 3 would supply raw standardized milk for processing from 8:30 a.m. to 10:45 a.m., and tank 3A would supply it from 10:45 a.m. to 1:30 p.m. Processed market milk flows to surge tank 18. The letter P indicates the time milk is held in the surge tank without any operation being performed.

HALF-AND-HALF.—Half-and-half is pasteurized in vat 5A between about 8:30 a.m. and 10 a.m. It is homogenized and cooled between about 10 a.m. and 10:55 a.m. Half-and-half would flow to surge tank 19. The letter K designates the time period the vat and the homogenizer are in use and the letter S represents the time the half-and-half is held in the surge tank (19).

BUTTERMILK.—Buttermilk is pasteurized in vat 5B between about 10:25 a.m. and 12:45 p.m. The buttermilk starter is manually added to vat 5B at the proper time during this cycle. Buttermilk is held overnight in the vat and flows directly to the fillers when ready for packaging. The letter M indicates the time the vat is in use. The letter V shows the time buttermilk is held in the vat prior to packaging.

CHOCOLATE DRINK.—Chocolate drink is pasteurized in vat 5 between about 12:10 p.m. and 1:40 p.m. It is homogenized and cooled between about 1:40 p.m. and 2:50 p.m. Chocolate drink would flow to surge tank 19. The letter N indicates the time the vat and the homogenizer are in use and the letter W indicates the hold period for milk in the surge tank.

Filling Cartons

BUTTERMILK.—Buttermilk would be put into cartons from 7:30 a.m. to 8:40 a.m. Buttermilk flows directly from vat 5B to filler 21. The letters AA indicate the time periods the equipment is used in performing the operation. The filling machine must be cleaned and sterilized before it is used for another product.

MARKET MILK.—After pasteurization and homogenization begins at 8:30 a.m., processed market milk begins to accumulate in surge tank 18. The half-gallon filling machine (20) would be started at 9 a.m., and the quart-pint filling machine (21) at 10:15 a.m. The total filling time for market milk is about 5 hours and 5 minutes. The two machines would operate simultaneously for only about 1 hour and 15 minutes. The letter X indicates the time period the equipment is used in performing the operation.

HALF-AND-HALF.—Filling operations for half-and-half would be from about 11:30 a.m. to 12:20 p.m. Half-and-half flows from surge tank 19 to filler 21. The letter Y indicates the time period the equipment is used in performing the operation.

CHOCOLATE DRINK.—Chocolate drink would be put into cartons from about 2:15 p.m. to 4 p.m.; it

would flow from surge tank 19 to filler 21. The letters BB indicate the time period the equipment is used. After filling is completed, the filler must be cleaned to prevent discoloration of the product that follows.

How the Plant Operates

A diagram of the suggested control panel for this plant is shown in figure 20.

The receiving of raw milk and the separation, standardization, pasteurization, and homogenization of market milk are performed in the same manner as discussed for the larger plant. Agitator and refrigerant controls, and switches for directing the flow of milk and milk products to the filling machines, are similarly operated.

This plant, however, does not have a second HTST pasteurization system for coffee cream, half-and-half, and chocolate drink; the mixing and blending vats are not equipped with load cells for automated weighing of the contents; and there is only one CIP unit.

Preparation, pasteurization, and homogenization of byproducts, and the use of the control panel in performing these operations, are discussed in the pages that follow. Use of the CIP unit and the order of flow of milk products to the fillers are also described. The flow of products through the receiving, separating, standardizing, pasteurizing, and homogenizing operations is shown in figure 21.

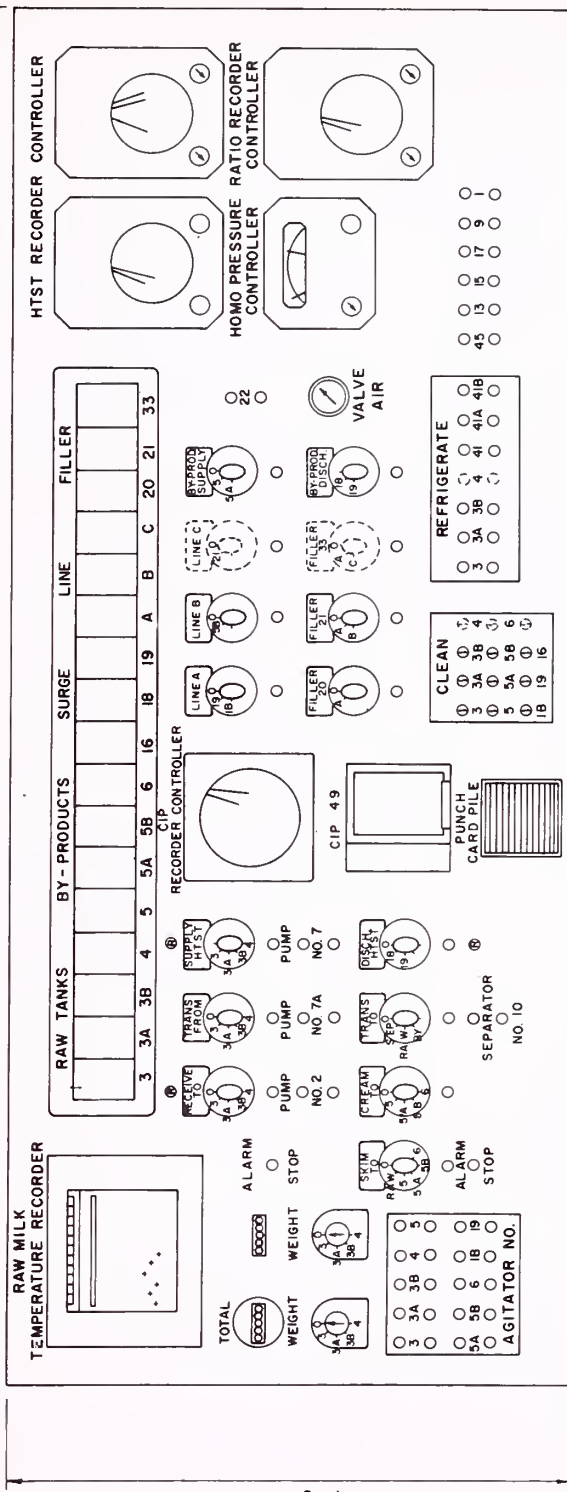
Operations other than those controlled from the control panel—filling, casing, and stacking; storing cases in cold room; loading out milk and milk products; handling empty cases; and manually cleaning equipment—are similar to those in the larger plant.

Standardizing

COFFEE CREAM.—Coffee cream would be made up in vat 5. The 12-percent butterfat product is diverted directly from the separator to vat 5. The weight of this product may be determined by measuring the volume in the vat with a graduated, sanitary dip stick. The 40-percent cream required is added manually. The 3.8-percent raw milk needed would be transferred to the vat by setting the "Transfer from" selector switch to the proper raw-milk storage tank, the "Transfer to" selector switch to vat 5, and pressing the buttons underneath each switch. The quantity transferred is controlled by the load cells in the legs of the raw-milk tanks. In this case the amount to be transferred must be subtracted from the total amount in the tank and the result set on the perimeter knob of the "Total weight" indicator.

HALF-AND-HALF.—In making half-and-half, the 12-percent butterfat product is diverted from the separator directly to vat 5A. The amount of 3.8-percent raw milk needed would be transferred to

11'-0"



- Ⓐ DENOTES RED LIGHT
- Ⓑ DENOTES GREEN LIGHT
- DENOTES PUSH BUTTON

SCALE - NONE

Figure 20.—A suggested control panel for an automated multipurpose milk plant handling 35,000 gallons of milk and milk products weekly.

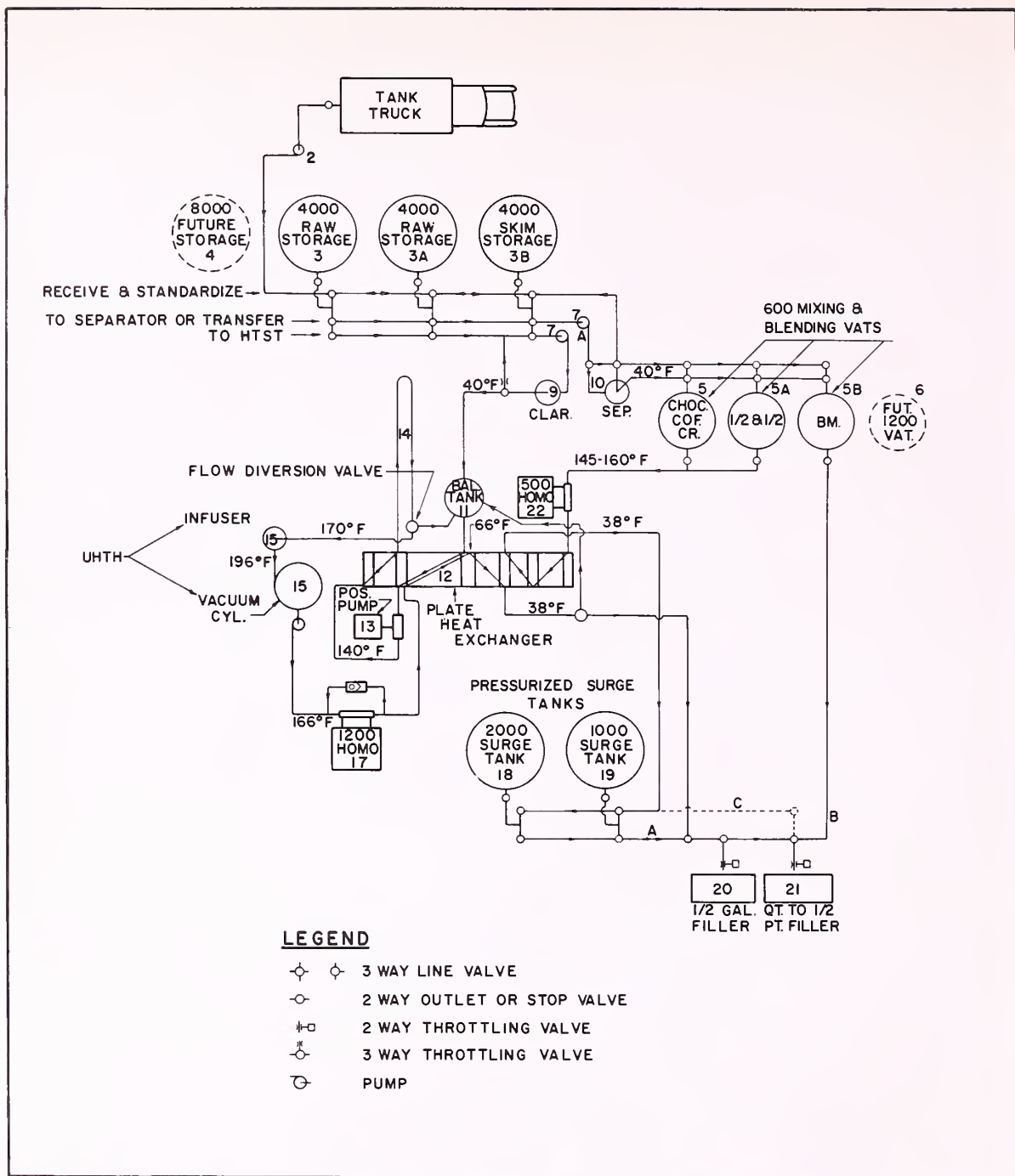


FIGURE 21.—Flow of milk and milk products through automated receiving, processing, and filling operations for a plant handling 35,000 gallons weekly

the vat in the same manner as that described for coffee cream.

CHOCOLATE DRINK.—Chocolate drink would be made up in vat 5. The skim milk and the raw milk would be transferred to the vat in the same manner as that described for making up coffee cream; chocolate syrup would be dumped manually into the vat.

BUTTERMILK.—Buttermilk would be made up in vat 5B by automatically transferring the required amounts of skim and raw milk and adding the starter manually.

Pasteurizing and Homogenizing

COFFEE CREAM.—Coffee cream would be pasteurized in vat 5, by opening a steam valve and

permitting steam to enter the heating jacket of the vat, heating the milk to a minimum of 144° F., and holding it at this temperature for 30 minutes. After pasteurization is complete, the "Byproduct supply" selector switch is set on vat 5, the "Byproduct discharge" selector switch on surge tank 18, and the buttons underneath the switches pressed. This allows the coffee cream to flow from vat 5 to homogenizer 22 through the cooling section of the plate heat exchanger (12), and into surge tank 18.

HALF-AND-HALF.—Half-and-half in vat 5A would be pasteurized and homogenized in the same manner as coffee cream; it would run into surge tank 19 after cooling.

CHOCOLATE DRINK.—Chocolate drink in vat 5 would be pasteurized and homogenized in the same manner as the half-and-half and coffee cream; it would run into surge tank 19.

BUTTERMILK.—Buttermilk would be pasteurized by the same procedure as that described for the larger plant, except that starter is not pasteurized separately; no starter vat is used in this plant.

Cleaned-in-Place Equipment

Only one automatic CIP unit (49) is needed to handle the cleaning in this plant. The cleaning operations are similar in this plant to those in the larger plant. The piping for cleaning mixing and blending vats with the automatic CIP system is shown in figure 22.

Labor Requirements

Seven workers, other than the office crew and route truck drivers, would be required to operate the suggested automated plant. This is five fewer workers than would be required to operate a nonautomated plant handling a similar volume. The reduction in the number of workers required in the automated plant is due to the use of automated and mechanized equipment which requires fewer workers or permits workers to perform additional duties.

The crew for the automated plant consists of a supervisor, a maintenance worker, a relief worker, and four other workers. The four other

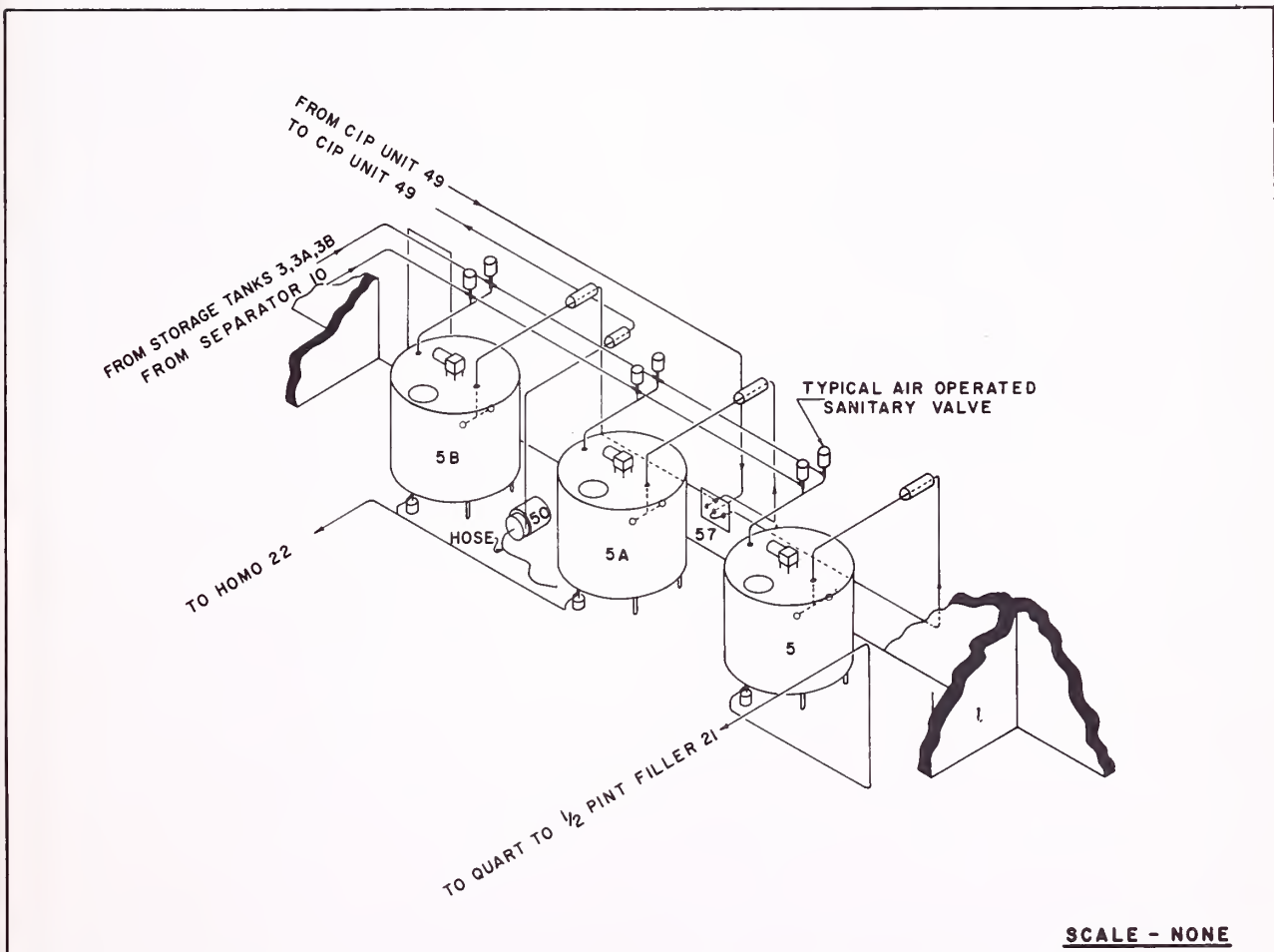


FIGURE 22.—This diagram shows piping for cleaning mixing and blending vats with the automatic CIP system in a multipurpose milk plant handling 35,000 gallons of milk weekly.

workers and the relief worker would perform the basic operations of receiving, processing, packaging, storing, loading out, and cleaning, and the receiving and handling of empty cases, cartons, and other supplies. The crew for the nonautomated plant would consist of 12 workers—a supervisor, a maintenance worker, a relief worker, and 9 other workers. The nine other workers and the relief worker would perform the basic operations in a nonautomated plant.

The supervisor for the automated plant would supervise all activities pertaining to the basic operations and also assist with the standardizing, pasteurizing, and homogenizing. The supervisor in a nonautomated plant would not have time to assist the other workers. The hours of duty for most workers in both plants would be from about 7:30 a.m. to 4:00 p.m.

Each type of plant would require one maintenance worker. This worker also would operate the refrigeration and heating systems.

In an automated plant, one worker would devote part of his time to receiving, grading, and separating milk. The same duties in a nonautomated plant require the full time of one worker.

The work of standardizing, pasteurizing, and homogenizing milk and milk products in the automated plant would require part of the supervisor's time and part of the time of the worker receiving raw milk, grading, and separating. Two full-time workers would be required to perform these operations in the nonautomated plant.

Three full-time workers would be required to perform the packaging, casing, and case stacking, and the operations in the empty-case room, dry storage room, paper-container room, and cold room in the automated plant; six workers would be required in the nonautomated plant. Automatic casers and case stackers, the stack feed magazine, automatic case unstackers, and automatic case dividers are responsible for this reduction.

The supervisor would perform the laboratory operations in both types of plant.

In the automated plant five workers would be required for washing and cleaning all equipment and work areas. In the nonautomated plant 10 workers would be required to perform all cleaning work because the plant would have no programed cleaned-in-place methods.

Costs and Possible Benefits of Labor-Saving Devices

The equipment required for the automated plant to reduce the labor requirements would consist of the control panel (1); an automatic CIP unit and three CIP solution return pumps (49 and 50); remotely controlled sanitary valves for automatically controlling the flow of milk and milk products; load cells for automatically weighing milk and milk products; a CIP transport tank washer (53); automatic casers (23 and 23A); automatic case stackers (25 and 25A); automatic case unstacker (29); the stack feed magazine (28); in-floor conveyor (27); and the automatic case divider (32). The estimated cost of the equipment would be \$95,000 greater than that required for a nonautomated plant.

It is estimated that the automated multipurpose milk plant handling 35,000 gallons of milk a week could operate with five fewer workers than a nonautomated plant handling the same volume. Based on an assumed cost of \$6,500 annually per worker (salary plus fringe benefits), the annual savings should amount to \$32,500. If 20 percent is allowed annually for ownership and operation costs (depreciation, maintenance, insurance, taxes, and interest), the costs would amount to \$19,000, and an annual savings of \$13,500 would result. The savings should amortize the cost of the equipment in about 7 years.

Production per man-hour of labor should be higher in the automated plant. On the peak production day (7,650 gallons) the estimated production per man-hour for the automated plant would be 136.5 gallons, compared to 79.5 gallons for the nonautomated plant. Based on a weekly production of 35,000 gallons, the production per man-hour would be 125 gallons for the automated plant and 73 gallons for the nonautomated plant. Roughly, the production per man-hour is 71 percent greater for the automated plant.

Machine-controlled operations should result in a reduction of the in-plant losses of milk. They should also provide for more stable standards than are obtained in a nonautomated plant using conventional equipment. No data are available for estimating the savings for these items.

Appendix: Refrigeration, Heating, Ventilation, and Air Conditioning

Plant Handling 105,000 Gallons of Milk Weekly

Refrigeration System

The refrigeration system for the suggested plant should be adequate to cool the milk and milk products when necessary and to maintain processed products at the required temperature in the cold room. Since ammonia is the refrigerant used in many dairy plants, this plant is set up for ammonia.

Milk and milk products would be cooled by circulating sweet water from an ice builder through insulated jackets in the tanks, vats, or plate heat exchanger. A reserve of ice is built up during slack periods to provide an adequate source of refrigeration when needed. Water enters the tank warm, circulates around the ice-covered coils, and leaves the tank cold.

The cold room would be refrigerated by four direct expansion cooling units. Each unit has coils through which ammonia circulates, cooling them. Air is blown over these coils by a fan in the unit, thereby cooling the room. The refrigeration calculations are based partly on data contained in "Refrigeration Engineering Application Data," April 1940, and "Air Conditioning Refrigeration Data Book," 1957.³

The refrigeration requirements presented herein are offered as a guide only, since many variables such as temperature differences, types of building materials used, and equipment arrangement affect the requirements of a particular plant. The

factors used in determining the sizes of equipment suggested for the plant are described in the following pages.

Milk Cooling Requirements

The milk cooling load would be based on the plant's peak day. On this day, 20,700 gallons of products would be cooled in the plate heat exchangers from 66° to 38° F., 1,800 gallons of cultured milk in the buttermilk vat from 100° to 50° F., 20 gallons of starter in the starter vat from 100° to 70° F., and 7,000 gallons of raw milk in the raw-milk storage tanks from 45° to 40° F.

The 20,700 gallons cooled in the plate heat exchangers would consist of 18,000 gallons of market milk, 1,350 gallons of half-and-half, 900 gallons of chocolate drink, and 450 gallons of coffee cream. Although only 1,800 gallons of buttermilk would be cooled in the buttermilk vat and 20 gallons of buttermilk in the starter vat, the refrigeration requirements are based on the sizes of the vats. The buttermilk vat has a capacity of 2,000 gallons and the starter vat has a capacity of 50 gallons.

For calculation purposes, the latent heat of fusion of ice is considered to be 144 B.t.u. (British thermal units) per pound, the weight of milk products 8.6 pounds per gallon, and the specific heat of milk 1.0. (The specific heat of milk is actually 0.94, but 1.0 is commonly used.) The milk cooling load (pounds of ice) for each item may be computed by the following formula. The sum of the requirements for the various items would give the total cooling load.

$$\text{Cooling requirements} = \frac{\text{Weight of milk} \times \text{specific heat of milk} \times \text{temperature change}}{\text{latent heat of fusion of ice}}$$

(pounds of ice)

The total refrigeration requirement for cooling milk when the various items are calculated by the above formula is 42,767 pounds of ice. Some losses occur from radiation, agitation, and pumping. Consequently, it is suggested that a safety factor of 10 percent be added to the requirements. Therefore, the total refrigeration requirement for

cooling milk would amount to 47,044 pounds of ice. An ice builder with a minimum capacity of 47,000 pounds is suggested.

Ice for cooling milk in the various components would be built up in the ice builder in the 16-hour period during that part of the day when the processing room is not in operation. This reduces the peak electrical load of the plant. The compressor capacity required for the ice builder is obtained by the use of the following formula. In using the formula, it is assumed that one ton of refrigeration is equal to 288,000 B.t.u. per 24 hours.

³ American Society of Refrigerating Engineers. Air Conditioning Refrigerating Data Book. Applications Vol. 6th ed., illus. New York. 1956-7.

Segal, S. Charles. Refrigeration Load Calculations—II. Temperatures Below 32° F.—Refrig. Engin. Applic. Data 12. Refrig. Engin. Vol. 39, No. 4, Sec. 2. April 1940.

$$\text{Compressor capacity (tons)} = \frac{\text{Amount of ice required} \times \text{latent heat of fusion of ice}}{12,000 \text{ B.t.u. per hour} \times \text{length of operating period}}$$

The compressor capacity required for building ice in the ice builder for cooling milk in the various components is calculated to be 35.28 tons. A 36-ton-capacity ammonia compressor with a 50-horsepower motor is suggested.

Cold Room Requirements

The factors which determine the refrigeration requirements of the cold room are the heat gains from walls, ceiling, and floor radiation; air changes in the cold room; milk cases; expenditure of electrical energy; and milk coming into the room. A heat gain also is incurred from workers storing and loading out stacks of cases in the room. Since only one full-time and one part-time worker would perform these operations in the proposed plant, this heat gain would be comparatively small and is included in the suggested safety factor. The refrigeration requirements for a cold room should be based on the peak average

hourly load. To determine the peak average hourly load for the room, it is necessary to calculate the peak average load for each factor. For this analysis it is assumed that the cold room refrigeration load would be handled in a 16-hour duty cycle, and 8 hours would be allowed for defrosting of cooler coils and for compressor downtime.

Heat gain through walls, ceiling, and floor is calculated by the formula shown below, on the basis of a cold room temperature of 35° F. and an outside temperature of 95° F. An average overall coefficient of heat transmission for the walls, floor, and ceiling of 0.0756 B.t.u. per square foot per hour per degree F. of temperature difference is suggested. This is equivalent to the heat loss caused by a wall section consisting of 8 inches of brick and 4 inches of rock wool insulation. The cold room for the suggested plant would have a surface area of 8,800 square feet.

$$\begin{array}{l} \text{Heat gain through} \\ \text{walls, floor, and} \\ \text{ceiling} \\ \text{(B.t.u. per hour)} \end{array} = \frac{\text{Surface area (square feet)} \times 0.0756 \text{ B.t.u. per square foot} \times \text{temperature change} \times 24}{16}$$

The peak average hourly load from heat gain through walls, ceiling, and floor is 59,875 B.t.u.

The heat gain through air changes is calculated by the following formula. The outside and inside temperatures for the room are the same as

those previously stated. Ten air changes per 24 hours are assumed for the room. The heat loss factor used is 2.53 B.t.u. per cubic foot per 24 hours for a temperature change of 60° F. The room contains 32,000 cubic feet.

$$\begin{array}{l} \text{Heat gain through} \\ \text{infiltration} \\ \text{(B.t.u. per hour)} \end{array} = \frac{\text{Volume of room (cubic feet)} \times 2.53 \text{ B.t.u.} \times \text{number of air changes per 24 hours}}{16}$$

The peak average hourly load from heat gain from air changes amounts to 50,600 B.t.u.

The milk cases are assumed to be made of steel wire and each would weigh 8 pounds. They would have a specific heat of 0.2 and enter the

room at a temperature of 95° F. The total number of cases that would enter the cold room on the peak processing day is 5,625. Room temperature would be 35° F. The formula for calculating the heat gain is as follows:

$$\begin{array}{l} \text{Heat gain from} \\ \text{milk cases} \\ \text{(B.t.u. per hour)} \end{array} = \frac{\text{Total number of cases entering room} \times \text{weight of case} \times \text{specific heat of case} \times \text{temperature change}}{16}$$

The peak average hourly load from heat gain from milk cases entering the cold room amounts to 33,750 B.t.u.

The heat input by electrical energy is based on the use of 8-horsepower motors on conveyor operating 8 hours, four 1/2-horsepower blower motors operating 24 hours, and 1,800 watts of electricity for lights for 10 hours.

The heat gain by electrical energy for the motors for the conveyor and blowers is calculated by the following formula. For the purpose of the calculation, one horsepower hour equals 3,700 B.t.u. per hour.

$$\text{Heat gain from motors (B.t.u. per hour)} = \text{Horsepower} \times 3,700$$

The peak average hourly load from heat gain from motors amounts to 37,000 B.t.u.

The heat gain from electrical energy used for the lights is calculated by the following formula. For the purpose of the calculation, one watt-hour equals 3.42 B.t.u. per hour.

$$\text{Heat gain from lights (B.t.u. per hour)} = \frac{\text{Number of watts}}{\text{of watts}} \times 3.42$$

The peak average hourly load from heat gain from lights amounts to 6,156 B.t.u.

$$\text{Product load (B.t.u. per hour)} = \frac{\text{Pounds of milk entering room} \times \text{specific heat} \times \text{temperature change}}{16}$$

The peak average hourly load from heat gain for products stored in the cold room amounts to 60,469 B.t.u.

The total refrigeration requirements of the cold room are 272,635 B.t.u. This total consists of the peak average hourly load for heat gain, 247,850 B.t.u., plus a 10-percent safety factor, 24,785 B.t.u.

$$\text{Refrigeration requirements (tons)} = \frac{\text{Peak average hourly load}}{12,000 \text{ B.t.u.}}$$

The total number of tons of refrigeration needed for the cold room is calculated to be 22.72. Thus, a 23-ton-capacity ammonia compressor with a 30-hp. motor is suggested for the proposed plant. Four cooling units are proposed for the cold room, and each unit would require a minimum of 5.68 tons of refrigeration. Each unit should have a capacity for 6 tons of refrigeration at a temperature difference of 10° F. between the refrigerant and the air being cooled.

System Needed for the Plant

The refrigeration system for the proposed plant based on the refrigeration requirements shown herein would consist of a 50-hp., 36-ton ammonia compressor (43), a 47,000-pound ice builder (47), a 30-hp., 23-ton ammonia compressor (44), four 6-ton cooling units (60), a 20-inch-diameter ammonia receiver 16 feet long (49), three sweet-water pumps (48), and a 60-ton evaporative condenser (50).

The cooling units would operate at a suction pressure of 39 pounds per square inch (p.s.i.) or a refrigerant temperature of 25° F. and the ice builder at 28 p.s.i. (refrigerant temperature 15° F.). Both compressors would operate from a common suction line.

A diagram of the suggested refrigeration system is shown in figure 23.

Operation of the System

Two automatic control devices are used in the refrigeration system—an ice thickness control and a thermostat in the cold room.

The total peak average hourly load from heat gain from the consumption of electrical energy in the cold room amounts to 43,156 B.t.u.

The heat gain from milk products entering the cold room is based on 22,500 gallons (193,500 pounds). The temperature of milk leaving the plate heat exchanger is 38° F. En route to the cold room a rise in temperature of 2° F. is assumed. Thus, milk enters the cold room at 40° F. The temperature of the cold room is 35° F. The heat gain from milk entering the cold room is calculated by the following formula:

The refrigeration system needed for the cold room should be sized to meet the peak average hourly load. As stated previously, this amounts to 272,635 B.t.u. The compressor capacity for the cold room would be determined by the use of the following formula. A ton of refrigeration is equal to 288,000 B.t.u. per 24 hours.

The ice thickness control automatically shuts off the 50-hp. compressor (43) when the ice on the coils of the ice builder (47) reaches a thickness necessary to provide 47,000 pounds of ice. This amount of ice closes solenoid valves S3 and S4. Closing valve S3 shuts off the supply of ammonia to the ice builder. Closing valve S4 diverts the ammonia suction through the back pressure valve (BPR) set at 30° F., which helps hold ice on the coils.

The startup of the ice builder could be automatic, but it is believed desirable to start it manually. The switch for the startup would be located in the refrigeration equipment room.

The thermostat automatically starts the compressor (44) when the temperature of the cold room rises to 38° F. When the compressor starts, solenoid valve S2 opens and provides liquid ammonia to the cooling coils for refrigerating the room. When the temperature of the room reaches 35° F., the thermostat stops the compressor, and solenoid valve S2 closes and cuts off the supply of ammonia to the coils.

At night when compressor 44 is off and compressor 43 is building up ice in the ice builder, compressor 43 will pump the supply of ammonia from the cooling coils. When the temperature of the coils rises above freezing, fans melt the ice from the coils.

Refrigeration to the raw-milk storage tanks and the buttermilk and starter vats is controlled by pushbuttons. When a pushbutton is depressed, solenoid valve S opens to admit sweet water to the equipment selected and the sweet-water pump starts circulation of the water.

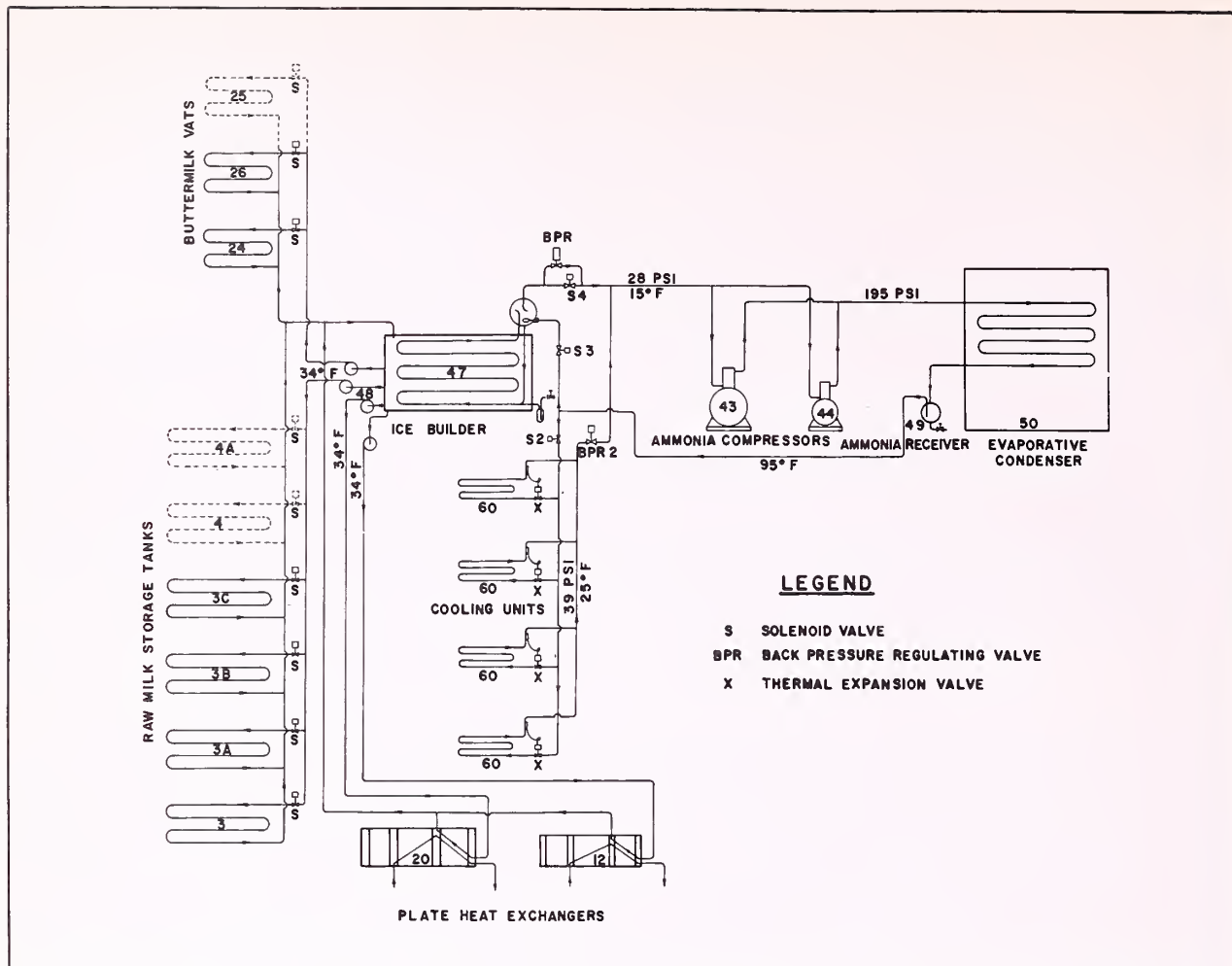


FIGURE 23.—Refrigeration system for a multipurpose milk plant handling 105,000 gallons weekly.

Heating System

A heating system would be required to provide hot water and steam for heating milk and milk products, for cleaning, and for heating the building. A heating system should be adequate to handle the peak heating requirements. The requirements for a particular plant would depend to some extent on the climatic conditions of the area in which the plant is located. Thus, heating data provided herein are offered as a guide only.

Milk and milk products, other than cultured

buttermilk and starter, would be heated by hot water and steam a total of 66° F. in HTST systems Nos. 1 and 2. The capacity of HTST system No. 1 is 3,000 g.p.h. (25,800 pounds) and the capacity of system No. 2 is 500 g.p.h. (4,300 pounds).

The energy requirements for heating milk and milk products in HTST systems Nos. 1 and 2 may be calculated by the following formula. For the purposes of these calculations the specific heat of milk is 1.

$$\text{Heat (B.t.u. per hour)} = \frac{\text{Pounds of milk}}{\text{per hour}} \times \frac{\text{temperature change}}{\text{change}} \times \frac{\text{specific heat}}{\text{heat}}$$

The heating requirements for heating milk and milk products in the HTST systems amount to 1,986,600 B.t.u. per hr.

Milk to be used for making cultured buttermilk would be heated by steam and hot water in the 2,000-gallon buttermilk vat a total of 140° F. for 45 minutes. Heating also would be required for

the starter prepared in the 50-gallon starter vat; but since it would not coincide with the heating of the 2,000-gallon buttermilk vat, no heating requirements are calculated for it. The heating requirements for the cultured buttermilk preparation may be calculated by the following formula.

$$\text{Heat (B.t.u. per hour)} = \text{Pounds of buttermilk} \times \text{temperature change} \times \text{specific heat}$$

Since the heating period is only 45 minutes, the hourly heat requirement figures obtained by the formula would need to be adjusted. The adjusted figure amounts to 3,210,667 B.t.u. per hour. This represents the heating requirements for buttermilk.

Hot water would be needed for the CIP circulating units for cleaning equipment. This heating requirement would be based on 3,000 g.p.h. (25,100 pounds) and a temperature difference of 60 degrees, assuming a temperature of 60° F. for inlet water and 120° F. for outlet water. The specific heat of water is 1.

The energy requirements for heating hot water for cleaning with the CIP circulating units would be calculated by the same formula suggested for calculating the heat requirements of the HTST systems. The heating requirements for heating water for cleaning amount to 1,506,000 B.t.u. per hour.

The energy requirements for heating milk and milk products, buttermilk, and water for cleaning total 6,703,267 B.t.u./hr. Calculation of the energy requirements for heating the plant are not shown here, but the requirement is given consideration in the discussion of the sizes of boilers suggested for the plant.

In calculating the heating requirements for milk and milk products in HTST systems Nos. 1 and 2, the buttermilk in the buttermilk vat, and the water for cleaning with the CIP units, one boiler horsepower is equivalent to the heat required to evaporate 34.5 pounds of water in one hour. This is equivalent to the heat output of 33,524 B.t.u. per hour. Since the water is below 212° F., a common practice is to use 35,000 B.t.u. per hour instead of 33,524 B.t.u. per hour when converting British thermal units to horsepower.

Dividing 6,703,267 by 35,000 for converting the heating requirements to boiler horsepower, gives 191.5. Thus, a 191.5-b.hp. steam generator is needed to provide the hot water and steam needed for heating the milk and milk products and the water for cleaning purposes.

Two 100-b.hp. steam boilers (51) are suggested for the plant. The units may be operated at 50 percent over the rated capacity continuously, or 100 percent over the rated capacity for short periods. Thus, in addition to providing heat and steam for heating milk and milk products and water for cleaning, these boilers should also be capable of providing heat for the plant.

The tanker-receiving shelter and the refrigeration room would be heated by unit heaters (61) suspended from the ceiling. The heaters are controlled by thermostats. The boiler room would require no heat other than that radiated from the boiler. The processing and filling room, empty-case storage room, dry storage room, paper-con-

tainer storage room, laboratories, lockers, and toilets would be heated by ducts from air circulation and heating units (72 and 73) located on the roof over the empty-case storage room.

The office would be heated by ducts from another air circulation and heating unit (71) located on the roof over the general office.

Ventilation and Air Conditioning

The refrigeration room and the boiler room would be ventilated by window fans.

The processing and filling room, the empty-case storage room, dry storage room, paper-container storage room, laboratories, and locker and toilet room are ventilated by ducts from a 20,000-c.f.m. air circulation and heating unit (72) located on the roof over the empty-case storage room, and from an air circulation and heating unit (73), circulating 5,000 cubic feet of air per minute, located on the roof over the paper-container storage room. These units mix fresh outside and plant air, filter and heat it, and return it to the plant via the duct system.

The processing and filling room will have one complete air change every 3 minutes to keep down humidity. Other areas have air changes every 7 minutes. This means the plant would operate under a slight positive air pressure, which reduces the entry of nonfiltered air through doors.

The office area is ventilated by a 10,000-c.f.m. air-conditioning unit (71) on the roof; this unit is similar to the one used for the plant, except that an additional cooling coil is provided for summer-time cooling. The refrigerated coil is thermostatically controlled.

Both units employ two-speed fans. Slow speed is used for winter heating and high speed for summer ventilation or air cooling.

Plant Handling 35,000 Gallons of Milk Weekly

Refrigeration System

Except for size, the refrigeration system for plant handling 35,000 gallons weekly is the same as that suggested for the larger plant.

Milk Cooling Requirements

The milk cooling load would be based on the plant's peak volume day. On the peak day 7,050 gallons of products would be cooled at the plate heat exchanger. Of this volume, 6,000 gallons of market milk would be cooled from 66° to 38° F., and 1,050 gallons of half-and-half and chocolate drink would be cooled from 80° to 38° F. In addition, 600 gallons of cultured buttermilk would

be cooled in the buttermilk vat from 100° to 50° F., and 4,000 gallons of raw milk in the raw-milk storage tanks from 45° to 40° F.

The total refrigeration requirements for cooling milk are 15,653 pounds of ice. If 10 percent is allowed for losses from radiation, agitation, and pumping, the total requirements amount to 17,218 pounds of ice. An 18,000-pound ice builder is suggested.

The compressor capacity required for the ice builder is 13.5 tons. Therefore, a 15-ton capacity ammonia compressor with a 20-hp. motor is suggested.

Cold Room Requirements

The factors that determine the refrigeration requirements of the cold room are the same as those listed for the plant handling 105,000 gallons weekly.

The heat gain through walls, ceiling, and floor for the cold room is based on 4,840 square feet of surface area, a cold room temperature of 35° F., an outside temperature of 95° F., and a coefficient of heat transmission of 0.0756 B.t.u. per square foot per degree F. temperature difference. The peak average hourly load from heat gain through walls, floor and ceiling amounts to 32,931 B.t.u.

The heat gain through air changes is based on 15,600 cubic feet of space, a heat loss factor of 2.53 B.t.u. per cubic foot per 24 hours for a temperature change of 60° F., and 10 air changes per 24 hours. The peak average hourly load from heat gain from air changes amounts to 24,668 B.t.u.

The heat gain from milk cases is based on 1,912 cases entering the room in 24 hours (an average hourly rate of 79.67 cases), a weight of 8 pounds per case, cases having a specific heat of 0.2, and a temperature difference of 60° F. The peak average hourly load from heat gain from milk cases entering the cold room amounts to 11,472 B.t.u.

The heat input from the utilization of electrical energy in the room is based on motors having 6 horsepower, and 1,200 watts in electric lights. It is assumed one horsepower-hour equals 3,700 B.t.u. and one watt-hour equals 3.42 B.t.u. The peak average hourly load from heat gain from electrical energy amounts to 26,304 B.t.u.

The heat gain from milk entering the cold room is based on the peak day's volume of 7,650 gallons (65,790 pounds), milk with the specific heat of 1, and a 5° F. temperature change.

The peak average hourly load from products stored in the cold room amounts to 20,559 B.t.u.

Total refrigeration requirements of the cold room are 127,527 B.t.u. per hour. This total consists of the peak average hourly load from heat gain (115,934 B.t.u.) plus a 10-percent safety factor (11,593).

The total number of tons of refrigeration needed for the cold room is 10.6. Thus, an ammonia compressor with a capacity of 11 tons and a 15-hp.

motor is suggested. Two cooling units are proposed for the cold room; each unit would require a minimum of 5.3 tons of refrigeration. Each unit suggested should have a capacity for 6 tons of refrigeration at a 10° F. temperature difference between the refrigerant and the air being cooled.

System Needed for the Plant

The refrigeration system suggested for the plant, based on the requirements shown herein, would consist of a 20-hp., 15-ton ammonia compressor (36), an 18,000-pound ice builder (38), a 15-hp., 11-ton ammonia compressor (35), two 6-ton cooling units (42), a 20-inch-diameter ammonia receiver 12 feet long (40), a sweet-water pump (41), and a 30-ton evaporative condenser (37).

Two cooling units would operate at a suction pressure of 39 pounds per square inch at a refrigerant temperature of 25° F., and the ice builder at a suction pressure of 28 p.s.i. at a refrigerant temperature of 15° F. Both compressors would operate from a common suction line.

A diagram of the suggested refrigeration system is shown in figure 24.

The operation of the refrigeration system for the plant would be similar to the system described for the larger plant.

Heating System

The heating system for the plant handling 35,000 gallons of milk and milk products weekly would be needed for the same purposes and would be similar to that described for the plant handling 105,000 gallons. The heating requirements for the respective items and the size of boiler needed would be computed by the same formulas.

Milk and milk products other than buttermilk in this plant would be heated by hot water and steam in the HTST system a total of 66° F. The capacity of the HTST system is 1,200 gallons per hour (10,320 pounds). Milk for cultured buttermilk, coffee cream, half-and-half, and chocolate drink would be heated a total of 140° F. in the 600-gallon (5,160 pounds) vats (5, 5A, and 5B). The heating period assumed for each product is 30 minutes. Furthermore, it is assumed that only one product would be heated at a time.

The heating requirements for hot water and steam for cleaned-in-place equipment would be based on 1,200 g.p.h. (10,000 pounds) and a temperature difference of 66°.

The energy requirements for heating milk and milk products and water for cleaning amounts to 2,785,920 B.t.u. per hour. The heating requirements for heating the plant are not calculated. However, this requirement is given consideration in the size of the boiler suggested for the plant.

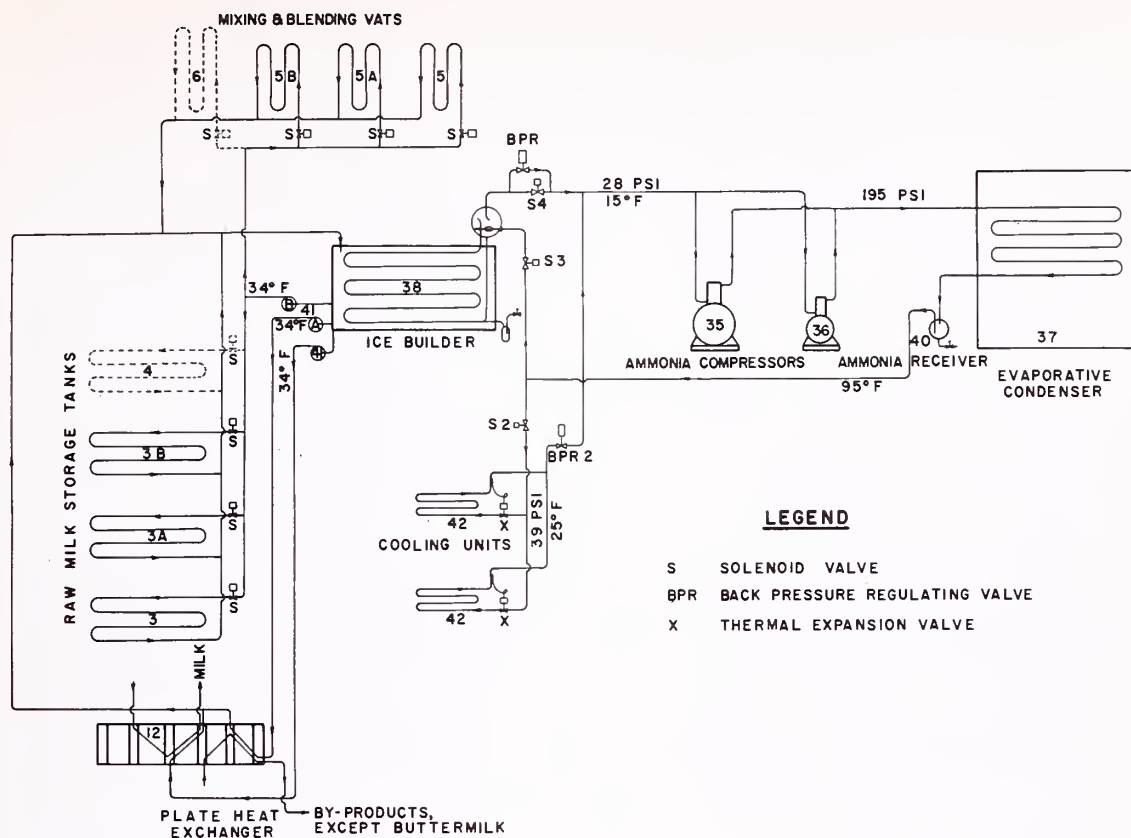


FIGURE 24.—Refrigeration system for a multipurpose milk plant handling 35,000 gallons weekly.

Converting the 2,785,920 B.t.u. per hour to boiler-horsepower gives 79.59 b.h.p. Thus, one steam boiler with a capacity of 80 b.h.p. per hour is suggested for the plant. Since this unit can be operated at a 50-percent overload continuously, or at a 100-percent overload for short periods, it should be capable of also providing heat for the plant.

The components which would be heated in this plant and the manner of heating are the same as those described for the larger plant.

Ventilation and Air Conditioning

The ventilation and air conditioning system suggested for this plant is the same type as that suggested for the larger plant. Two air circulating and heating units, mounted on the roof, are required for the plant. A unit (54) circulating 20,000 cubic feet of air per minute would be located over the paper-container storage room, and a unit (55) circulating 5,000 c.f.m. would be located over the main office.

